THE
POPULAR SCIENCE
MONTHLY

JULY, 1907

# WHAT WE OWE TO AGASSIZ[1]

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THIS day, one hundred years ago, was born in Switzerland a man-child destined to astonish and uplift the world. Christened Jean Louis Rodolphe, he was and is known as Louis Agassiz, or simply Agassiz, his eminent son being distinguished as Alexander.

Why is this centennial celebrated here and elsewhere? Rather, by such as know what Agassiz was, what he did, and what he tried to do, would it be asked, Why is not this day observed in all lands, by all classes, yea, even in behalf of animals, plants, the rocks and the very elements?

For, from a child, Agassiz loved nature and humanity. The one he strove to interpret, the other to cheer and enlighten. He was a naturalist in the broadest sense, a sense broader than is possible in these days. His thirst for knowledge was equaled only by his desire to impart it, and his ability to earn money was surpassed only by his determination to spend it for the welfare of man and the glory of God.

More or less complete accounts of Agassiz have been published in various books and periodicals. A partial list of these is included. By far the best, although lacking many desirable details and restricted by the relationship, is the "Life and Correspondence" by his wife. My admiration for this grows with each re-reading. In respect to both subject and style it might well be included among the entrance requirements in English. It portrays an eminent scholar, indefatigable collector and teacher, sincere patriot, staunch friend and fascinating personality in a manner so just, so vivid and inspiring that, were it practicable, in place of the many spoken observances of this centenary, I

[1] Address at the Centenary of Louis Agassiz delivered, at the request of President J. G. Schurman, in Barnes Hall, Cornell University, May 28, 1907.

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could wish that the coming Memorial Day might be partly devoted to its perusal—*out-of-doors*—by every man, woman and child.[2]

In enumerating the grounds upon which this commemoration might be well-nigh cosmic in its scope, so far as possible I shall use the words of Agassiz himself or of others fitly representing the several groups.

The following account of the "Glacial Theory" is condensed from the address[3] at the unveiling of the Agassiz tablet in our Memorial Chapel, June 17, 1885, by the geologist and paleontologist, Professor J. S. Newberry:

"In 1837 the Association of Swiss Naturalists met at Neufchatel, and Agassiz then advanced the theory of a general glacial epoch of which he may justly be called the author. At first it met with violent opposition [Marcou says, p. 108, 'it was like a pistol-shot fired into the midst of the assembly'], but this only stimulated those who had adopted it to greater enthusiasm in their researches. . . . One of the motives which led Agassiz to America was his ardent desire to see for himself whether the glacial record was the same for the New as for the Old World. . . . Many years before his death he had the satisfaction of knowing that his theory was applicable to the whole northern hemisphere, and the pleasure of studying a similar record in southern South America." I wish there were time to quote from Mrs. Agassiz's volume (pp. 317–332) the graphic, indeed thrilling, story of his life upon the glaciers. He once caused himself to be lowered into a crevasse to the depth of one hundred and twenty-five feet, when death would have attended either the fraying of the rope by sharp edges of ice or the dislodgement of the huge stalactites between which he had to steer his way.

Agassiz was a well-informed botanist. His "Lake Superior" and "A Journey in Brazil" deal largely with vegetation; two or three smaller papers are botanic, and one of the courses before the Lowell Institute was, he told me, upon trees and plants.[4] A member of the administrative staff of our College of Agriculture related to me the following incident: During Agassiz's stay here in 1868 he often walked about the then very open campus. She and her brother, little children, conceived a great admiration for him, called him "our Frenchman," and used to offer him flowers. On one occasion she was about to pluck a red clover upon which a bumblebee had just alighted.

[2] The only other comparable biography is the "Life, Letters and Works" by Marcou, and it will be quoted frequently. Its peculiarities are well stated in *The Nation* for May 7, 1896. In a letter to me, dated March 21, 1896, he expresses his regret at the inadvertent omission of "some of the best" from the enumeration of Agassiz's pupils and assistants.

[3] As printed in the "Proceedings in memory of Louis Agassiz and in honor of Hiram Sibley," pp. 11–12.

[4] May this be that which was given in 1853 under the title, "Natural History"?

He restrained her, saying gently, "Do not frighten it away; the bees are the friends of the flowers." [5]

Agassiz's concern for the promotion of agriculture was evinced by word and deed upon many occasions.[6] In 1861 he supervised the drawings for the "New Edition" of Harris's "Insects injurious to vegetation," and "rendered assistance by way of suggestion and advice throughout" the publication of the work that was the prototype of the later extensive reports and organizations, state and national, in the line of economic entomology. The last chapter of "A Journey in Brazil," published in 1868, was more than half devoted to the agriculture and forestry of that country.

So deeply interested was Agassiz in the problems involved in the improvement of domesticated animals that, at the close of his exhausting summer at Penikese, and only three months before his death, he wrote me a letter of 1,700–1,800 words devoted mainly to that subject. The following sentences are very suggestive:

> We naturalists can not afford the expense necessary for making the investigations and answering the questions about which farmers universally expect us to be prepared to give information. It would cost hundreds of thousands of dollars to study the embryology of the horse as I have studied that of the snapping-turtle. But turtle eggs can be had for the asking, while every egg and every embryo of the higher animals will cost the price of a mare or a cow, and so for other species. I do not know one scientific man in the world so placed that he could kill one hundred of these animals a year, for a number of successive years in order to study their embryology; and yet until this is done we shall go on groping in the dark as far as any real improvements in the breeding of stock are concerned.

It is probable that this topic occupied him in his last public effort, a lecture on "The Structural Growth of Domesticated Animals" before the Massachusetts State Board of Agriculture, only twelve days before his death.

On the twenty-eighth of May, 1874, the birthday of Agassiz next following his death, there was held here a Memorial Meeting.[7] It was addressed, among others, by the Hon. John Stanton Gould, then our non-resident lecturer on agriculture, who had witnessed interviews between Agassiz and farmers seeking information as to animals, crops and soils. He said "It was beautiful to see that illustrious man impart the needed facts in language perfectly adapted to the intellectual and scientific status of the inquirer."

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[5] See, also, the relation of a botanist, Professor C. F. Millspaugh, *Cornell Era*, June, 1907, p. 443, and "Proceedings of the Memorial Meeting of the Cambridge Historical Society," May 27, 1907.

[6] It is not easy to account for the omission of entries like *agriculture* and *farmer* from the indexes of the volumes by Marcou and Mrs. Agassiz.

[7] It was for the purpose of raising a sum to be added to the "Teachers and Pupils' Fund" in support of a scholarship at the Museum. There was raised $100, of which about one fourth was given by President White.

How clearly the situation was recognized by Agassiz himself is shown in the following paragraph from the preface to his "Contributions to the Natural History of the United States":

> There is not here [as in Europe] a class of learned men, distinct from the other cultivated members of the community. On the contrary, so general is the desire for knowledge, that I expect to see my book read by operatives, by fishermen, by farmers, quite as extensively as by the students in our colleges or by the learned professions, and it is but proper that I should endeavor to make myself understood by all.

For the means of carrying on the regular work of the museum, and for such special projects as are referred to above, Agassiz depended largely upon grants from the state legislature as recommended by the board of education. Many of the legislators were farmers or from agricultural districts, so that his efforts to improve the quality of domesticated animals and to check the ravages of insects were both natural and politic.

But it may well be doubted whether even the weighty facts and arguments at his disposal would have sufficed without the extraordinary influence of his personality and eloquence. This was alluded to by Oliver Wendell Holmes[8] in the sentence, "The hard-featured country representatives flocked about him as the fishes gathered to hear Saint Antony, as the birds flocked to hear the sermons of Saint Francis." It has been more fully described by Thomas Wentworth Higginson and Charles Mellen Tyler.[9] With the latter's permission I will quote it in advance, nearly *verbatim:*

> In 1861–2 I was in the Massachusetts Legislature and a member of the Committee on Education before which Professor Agassiz appeared to secure the annual appropriation for his museum. It was the year of the storming of Fort Sumter, of the attack upon a Massachusetts regiment passing through Baltimore, and of the first battle of Bull Run. Members of both houses of the Legislature foresaw a prolonged and bloody conflict, a great demand upon the Treasury, an increased and burdensome taxation to maintain the forces in the field. Our hearts were not high; we cut and slashed all bills of appropriation, and scrutinized with microscopic suspicion every bill of either house which looked to any increase of expenditure. Our committee anticipated the interview with Agassiz with some impatience and in a negative disposition of mind. We had, in fact, resolved beforehand not to recommend to the House and Senate the usual gift from the State. But when Agassiz appeared before us with his delightful accent and bland, persuasive, almost affectionate personal appeal to each of us, we wholly forgot the distress of the nation, the probable rejection of our recommendation by the two houses, and went over to Agassiz, horse, foot and dragoons, reported a bill for the usual outlay for his benefit, and to our surprise we carried it through.

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[8] In the letter declining the invitation to attend the unveiling of the Agassiz tablet, p. 7 of the "Proceedings" mentioned above.

[9] The former in the Boston *Transcript* for April 23, 1907, and the latter in the *Harvard Graduates' Magazine* for June, 1907, p. 778.

Agassiz was born near Lake Neufchatel in the region known as the Seeland of Berne. His early home was literally surrounded by lakes, rivers and marshes. "Almost as soon as he was able to move alone he took to water like a young duck. All the fishermen became at once very fond of the little fellow, and there was a friendly rivalry among them to get him into their boats and show him how to catch fish."[10]

This friendly relation with the takers of fish was maintained throughout his life. Wherever he went he visited the markets and ascertained who were the most enterprising and intelligent purveyors. From them he gained not merely specimens but information, and to them he imparted his own knowledge in appropriate terms. One of his closest friends was Captain N. E. Atwood, of Provincetown, Mass., whose personal knowledge of marine fish and fisheries was so highly estimated by Agassiz that, upon the latter's suggestion, he was invited to give a course of lectures before the Lowell Institute.

In 1853 he issued a circular asking for collections of fishes from various fresh-water systems of the United States. . . . To this he had hundreds of answers, many of them very shrewd and observing. . . . A great number and variety of collections . . . were forwarded. As to the marine forms, "many a New England captain, when he started on a cruise, had on board collecting cans,[11] furnished by Agassiz, to be filled . . . and returned." (Mrs. Agassiz, pp. 518–519.)

The participation of women in any memorial of Agassiz is most natural. His mother was his most intimate friend and his letters to her from America are simply delightful. At the museum his lectures were open to women as well as men. He had great sympathy with the desire of women for larger and more various fields of study and work, and a certain number, including the librarian, have always been employed as assistants. For eight years (1855–63) he lectured almost daily in a school conducted by his wife; and upon her intellectual companionship and cooperation he became so dependent that he once declared to me, with signs of deep emotion, "Without her I could not exist." Never from his lips did I hear a word that might not have been spoken in her presence.

In 1873, of the forty-four teachers admitted by him as pupils at the Penikese school, sixteen—more than one third—were women. Coeducation—then hotly debated and regarded by some as a bugbear—had not with him even the dignity of existence as a problem. He declared that he had "no hesitation from the start." His attitude was certainly consistent; among the theses defended at his graduation in 1830 one was entitled *Femina humana mari superior.* Are some male members of this university concerned lest that phrase become the appropriate motto for the College of Arts and Sciences?

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[10] Marcou, I., pp. 7–8.

[11] One of these cans arrived at Penikese during the last summer of his life, and I well recall the interest, akin to that in a Christmas box, with which Agassiz and his assistants and pupils drew forth the contents.

Before me are representatives of the African race, members of the university in full enjoyment of all its educational advantages. Fitly may they unite in honoring the memory of one who so effectively aided the establishment of this cosmopolitan institution. For, whatever may have been Agassiz's technical views as to the diversity of origin of the so-called human races, and however he may have deprecated amalgamation and the premature conferring of certain political privileges, his correspondence with Dr. Samuel G. Howe leaves no doubt as to his position upon the fundamental issue:

> The negroes should be equal to other men before the law. . . . They are entitled to their freedom, to the regulation of their own destiny, to the enjoyment of their life, of their earnings, of their family circle. . . . It is one of our primary obligations to remove every obstacle that may retard their highest development.

One of Agassiz's two daughters married Quincy A., brother to Robert Gould Shaw, commander of the "Fifty-fourth," the first of the two Massachusetts colored regiments in the Civil War. On the eighteenth of July, 1863, Colonel Shaw fell at Fort Wagner and was there buried with his dusky followers. So far from regretting the circumstances of his death or the nature of his last resting-place, the hero's name has been repeated in the second generation.

By none should the memory of Agassiz be cherished more devoutly than by the science teachers of America. I refer here not so much to the favored few[12] who enjoyed his direct instruction whose office is so finely drawn in these lines by James Russell Lowell:

> He was a Teacher; why be grieved for him
> Whose living word still stimulates the air?
> In endless file shall loving scholars come,
> The glow of his transmitted touch to share.

From highest to lowest, every teacher of natural science in this country is indebted to Agassiz for improvements in methods, for elevation of public respect, and for increase in compensation.

Upon the point last named Agassiz had cause for entertaining decided views. For years his regular salary was only $1,500; indeed, not until the very end did a gift relieve him entirely from the necessity for outside labors which doubtless shortened his days. His last letter to me, dated November 25, 1873, contained the following significant sentence: "If scientific men are ever to be placed on a proper footing of independence in this country, it is for the younger to work for it. They have a fine opportunity of doing it by pointing out what the older men have done on a starving allowance." On an earlier occasion he declared

[12] For example, A. C. Apgar, of Trenton; W. O. Crosby, of Boston; W. K. Brooks, of the Johns Hopkins; David S. Jordan, of Stanford; C. S. Minot and W. H. Niles, of Boston; T. B. Stowell, of Potsdam, N. Y.; C. O. Whitman, of Chicago, and A. E. Verrill, of Yale.

that thereafter he would not give a public lecture for less than $500, in order to let those who held the purse-strings appreciate the value of such services.[13] While he did not hesitate to accept for the museum, at a low remuneration, or even with none, the services of young men who desired at the same time to learn from him or to enjoy opportunities for research, my personal experience with him during four years and one summer warrants me in saying that in cases of a different sort he was liberal and even generous.

At the middle of the last century American naturalists were few, scattered and little understood. Commonly their vocation was medicine, and their botanic and zoologic avocations were rather condoned than commended. The prevailing notions are embodied in this anecdote: A few years after his arrival in America Agassiz made one of a small party of Harvard professors who traversed the White Mountain region in a carriage driven by a countryman. Three of them were vivacious, restless, and on the lookout for specimens. They would call a halt; leap from the vehicle before it stopped; dash over the fields, and return with prizes in their boxes, in their hands and pockets, and even pinned upon their hats. The fourth, Professor Felton, the brother-in-law of Agassiz, sat quietly in his corner reading a favorite Greek author. When the bewildered driver could stand it no longer he elicited from Felton information which led him to view the behavior of the others with compassionate toleration. His interpretation was thus conveyed to the innkeeper at the close of the day: "I drove the queerest lot you ever saw. They chattered like monkeys. They wouldn't keep still. They jumped the fences, tore about the fields, and came back with their hats covered with bugs. I asked their keeper what ailed them; he said they was *naturals,* and judgin' from the way they acted I should say they was."

Before long, however, in and about Cambridge and wherever Agassiz remained for any time, he and those inspired by him made the pursuit of natural history not only familiar and reputable, but almost fashionable. Yet when this university opened the collecting of specimens was so unusual that the following incident is related to me by Winfield Scott Merrill, who was here in 1868–9:

> While walking in the country I saw a boy holding a horse, and he told me it belonged to a "crazy Dutchman" over in the woods looking for birds' nests.[14]

In an article, "Louis Agassiz, Teacher,"[15] his ideas and practise as to methods of teaching are considered by me at some length. On the present occasion I quote from E. L. Youmans, late editor of the Popular Science Monthly:

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[13] This was said to Professor Wyman in my presence, November 17, 1866.

[14] This was printed in the *Cornell Era* of the period, but by some it was regarded as a myth.

[15] In the June number of the *Harvard Graduates' Magazine.*

Agassiz had a profound interest in popular education, but the soul of that interest was for improvement in its methods. In the matter of public instruction he was a revolutionist and a propagandist. He warred with current ideas and consecrated practises. He condemned in the most emphatic way the wretched lesson-learning routine that prevails in the schools. . . . He never wearied in the endeavor to propagate more rational opinions, and we can not doubt that the seed thus sown will yet ripen into most valuable fruit. He denounced our wordy and bookish education as baseless and unreal, and demanded such a change in our system of instruction as shall bring the pupils face to face with nature herself, and call out the mind by direct exercise upon phenomena—the facts, laws, relations and realities of the world of experience.

The abundance of this educational fruit is indicated by Liberty H. Bailey, an exponent alike of "nature-study teaching" and of "science-teaching for science' sake":

Agassiz gave us the motto, "Study nature, not books." He taught the study of nature by the natural method. . . . And, although his teaching may not have been nature-study, as we understand the term—being given from the investigator's or the specialist's view-point, and intended primarily for students and adults—the present nature-study movement undoubtedly is a proximate result of the forces that he set in motion. ("The Nature-study Idea," pp. 5, 6, 8.)

Summer schools and biologic stations are now so common at the seashore and by inland waters that those who attend them for instruction or research do not always realize their origin with Agassiz, thirty-five years ago in the establishment of "The Anderson School of Natural History at Penikese Island." Its history is given in the report of the trustees, and various aspects of it have been presented in the publications enumerated in my article, "Agassiz at Penikese."[16] The first session was directed by Agassiz himself, in the last summer of his life; the second by his son. "Although," to quote Mrs. Agassiz (p. 772), "the Penikese school may be said to have died with its master, it lives anew in many a seaside laboratory organized upon the same plan."

Our proneness to forget the pioneers by whose ideas and labors we profit was noted by Agassiz himself in his Humboldt Address (pp. 5, 6):

The fertilizing power of a great mind is truly wonderful; but as we travel farther from the source, it is hidden from us by the very abundance and productiveness it has caused.

Particularly should this day be remembered by that apparently diminishing number of collegiate teachers who hold that the kingdom of scholarship cometh not with observation nor with the assumption of millinery. In this country Agassiz wore no decorative ribbon of any kind, although he possessed that of the Red Eagle of Prussia and that of the French Legion of Honor. Although impressive in aspect and dignified in manner, he was extremely simple and unpretending in his ways, and did not like to make an appearance different from that of ordinary people in his neighborhood. He was of a joyous disposition

[16] *American Naturalist*, March, 1898.

and upon occasion he could be merry as a child. But for his merriment time and place must be fitting; *Dulce est desipere in loco.* He upheld the dignity of scholarship, and regarded university property and university time as consecrated to the loftiest functions.

Agassiz has not generally been thought of as a disciplinarian; yet a single incident would justify the celebration of this day by those who regard the saying, "Boys will be boys," as inapplicable beyond the secondary school. Early in the summer at Penikese three young men committed a breach of decorum which some might consider amusing. The next morning Agassiz simply announced that they had shown themselves undeserving and would leave the island before noon.

To the public Agassiz was best known through his lectures before the Lowell Institute and elsewhere, and by the "Methods of Study in Natural History." But an enormous amount of technical work is represented by his European publications, by the four volumes of the "Contributions to the Natural History of the United States," and by his papers of greater or less length upon many zoologic topics. Marcou enumerates 425 titles. Coues thinks[17]

**the greatest practical boon he ever conferred upon working naturalists was his "Nomenclator Zoologicus," with its accompanying index—the veriest drudgery imaginable for an author, yet drudgery of a kind that no hack or mere compiler could have performed; and only those who have to keep it at their elbows can be sufficiently grateful for this instrument.**

But working zoologists, anatomists and chemists are indebted to Agassiz for another practical service which probably could not have been rendered so efficiently by any other human being, *viz.*, the remission, by act of congress, of the tax upon alcohol used for scientific purposes. Alcohol is consumed largely in chemical laboratories, and it was nearly the only museum preservative in use before the comparatively recent introduction of formal. Representations to congress were made by Spencer F. Baird and others concerned, but it is doubtful if they would have succeeded without the exercise of Agassiz's commingled powers of conviction and persuasion.

No native scientist did more than Agassiz to establish and maintain the intellectual independence of his adopted country.[18] Aside from his published works, his training of young men, his founding of the museum and his provision of means for employment and research that might otherwise have been sought abroad, upon at least two occasions he urged such cultivation of science in this country as should free American naturalists from the necessity of looking up to Europeans as their leaders and guides.

At the annual meeting of the Boston Society of Natural History,

[17] Review of "Marcou" in *The Nation*, May 7, 1896.

[18] Unconsciously I have used here nearly the words of Oliver Wendell Holmes in his letter referred to above.

May 17, 1848, "he made a most earnest and stirring appeal" in that direction. Three years later he made a declaration of sentiment and policy, emphatic, specific and self-sacrificing. This shall be given in his own words:[19]

> Twenty years ago I was present at a meeting of the American Association for the Advancement of Science, held in Cincinnati, where specimens from all parts of the west were brought together to be seen by the scientific men of the east. . . . When one of the members of the association moved that to make the best use of these collections they should be sent to Europe to be identified by paleontologists and zoologists of the old world, I opposed that motion as earnestly as I could, stating that it would be an acknowledgment of inferiority on the part of America from which we could never rise again. . . . My motion was carried, and yet I remained under the imputation, which was loudly expressed by some, that I had carried a big job; that my motion had been made in order that I might have the benefit of describing those specimens, and thus raise my reputation. I resolved then to myself, but never spoke of it before, that I would never describe an American fossil, and I have kept my resolve. The progress since then has been such that now an American student scouts the idea of sending a piece of work to a European ordeal.

Agassiz came to America upon a scientific mission provided for by the King of Prussia. He found here unlimited material for research, the chance of earning by lecturing the means of repaying obligations incurred by his European publications, and a cordial welcome alike from naturalists, from society and from the people at large. Changed political conditions rendered his return less desirable, and he accepted a professorship in the newly-established Lawrence Scientific School at Harvard University.[20] Ten years later he declined a favorable and repeated offer of a chair in the Paris Museum of Natural History. When the Civil War broke out "no American cared more than he for the preservation of the Union and the institutions it represented." Indeed, "he was naturalized in the darkest hour of the war, when the final disruption of the country was confidently prophesied by her enemies. By formally becoming a citizen of the United States he desired to attest his personal confidence in the stability of her constitution and the justice of her cause."[21]

Although the subjects of Agassiz's studies had commonly to be killed, he was not a sportsman. "His passion for Natural History never carried him so far as to shoot birds or animals for sport." The

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[19] From the report of the meeting of the joint committee on education of the Massachusetts Legislature as printed in the *Boston Weekly Spectator* for February 12, 1871. Among other obvious misprints Agassiz is made to say that his protest was made "twenty-four" years ago, which would be 1847, whereas the first Cincinnati meeting of the American Association for the Advancement of Science was in 1851.

[20] His first wife died July 27, 1848, and in the spring of 1850 he married Miss Elizabeth Cabot Cary, of Boston, who became his "guardian angel."

[21] Mrs. Agassiz, pp. 568, 570.

creatures needed were put to death, as were the mortally wounded soldiers by old Ambroise Paré, "doucement et sans cholère."

An even more impressive exemplification of the apparently paradoxical character of Agassiz was his attitude toward theology. His writings contain abundant evidence of his firm belief in the existence of a Creator, but he would not discuss dogmas and repelled as impertinent the too prevalent American fashion of asking what church a man attends. So while criticized as a bigot by some scientists he was denounced as an infidel by some theologians because he could not reconcile the facts of geology with the literal interpretations of Scripture. In this regard, with Lord John Russell in politics, Agassiz might have said he was "sure he was right because both parties found fault with him." To the "righteous overmuch" who may hesitate to unite in this commemoration of one who seemed to make light of Genesis and to pass over Adam as if he had never existed, is commended reflection upon the following incidents: On the eighth of August, 1873, commenting on the death of an assistant, he said, "My time will come soon, and I am ready." In four short months that time had come.

On the first of May, 1868, to my remark that I could not understand why Providence and the community had allowed him to lack the means for the complete development of his plans, he replied, "I suppose it is all right; had I obtained all I wished it might have gratified my ambition too much."

At the opening of the Penikese School, July 8, 1873, Agassiz said: "I think we have need of help; I ask you for a moment to pray for yourselves." The incident was commented upon as follows by Henry Ward Beecher:[22]

> It seems to us that this scene of Agassiz and his pupils with heads bowed in silent prayer for the blessing of the God of Nature to be given to that school then opened for the study of nature, is a spectacle for some great artist to spread out worthily upon canvas, and to be kept alive in the memory of mankind. What are coronations, royal pageants, the parade of armies, to a scene like this? It heralds the coming of the new heavens and the new earth—the golden age when nature and man shall be reconciled, and the conquests of truth shall supersede the conquests of brute force.

As an American, as a student and teacher of science, and as a member of Cornell University,[23] I might, like hundreds of others, take some part in this commemoration. But there are special reasons why, when possible, I have complied with requests to speak or write of Agassiz, and why the invitation to give the present address was accepted with joy and with a sense of obligation, notwithstanding its preparation has seriously

[22] In the *Christian Union*, July 15, 1873, p. 51. See also "The Prayer of Agassiz," by Whittier.

[23] As delivered the address described what Agassiz did for Cornell University, directly and indirectly; see the *Cornell Era* for June, 1907, pp. 441–446.

interfered with prior plans for purely scientific work. I am one of the few survivors of those who were directly associated with Agassiz as pupils, assistants or colleagues. He inspired me with interest, with admiration, with respect, nay, almost veneration. No shadow ever came between us. Whatever benefits he may have conferred upon others, I have reason to believe that, outside his family circle, there is no one, living or dead, who has such cause for gratitude and affection in return for counsel, for encouragement, for opportunity, and even for material aid in the form of specimens or information.

The following statements are based not only upon my vivid recollections but upon my diaries and upon the letters of Agassiz, all of which have been preserved.

I am unwilling to speak of myself on this occasion, and yet I do not know how else I can do justice to one of the most beautiful sides of his character. His sympathy for all young students of nature was one of the noblest traits of his life. It may truly be said that toward the close of his career there was hardly one such in this country who was not under some obligation to him.[24]

As of yesterday I recall the first interview, now half a century ago. At the age of fifteen (in the middle of the last century a considerably less mature epoch than at present) some observations of mine upon spiders were brought to the notice of Agassiz by one of his assistants, James E. Mills, and led to an invitation to visit him. In my "Entomological Diary" he is described as a "very pleasant, fine-looking gentleman." Now I should write, "The most fascinating and magnificent of men."[25] At once I appreciated the saying current in Cambridge that in winter one needed an overcoat less while passing his house. His commendation of the spider essay led my parents to grant my request to prepare for the profession of naturalist.

That preparation comprised (1) Two more years of Latin and Greek to complete the Harvard entrance requirements in those languages; (2) additions to the collection of insects that formed the nucleus of the collection at Cornell; (3) reading the first two volumes, just issued, of Agassiz's "Contributions to the Natural History of the United States" (Turtles, and Essay on Classification). This was done before breakfast, and such was my conviction of its value that, although the text was largely unintelligible at that stage of my progress, I felt fortified for the ordinary tasks of the day somewhat as is the religious neophyte by his matutinal fasting and prayer. The experience is related as a warning rather than as an example, but it illustrates the influence unconsciously exerted by Agassiz upon those whom he had welcomed to the scientific fold.

That influence was similarly illustrated while attending his lectures

[24] Slightly altered from Agassiz's address on Humboldt, p. 44.

[25] In a letter dated Charleston, S. C., March 12, 1853 (printed in the *Century Magazine* for December, 1903, p. 188), Thackeray describes Agassiz as a "delightful, *bonhommious* person, as frank and unpretending as he is learned and illustrious."

at Cambridge in my first year. No topic was so vital as the general problem of animal life, and no expositor could compare with Agassiz. As an outlet for my enthusiasm each discourse was repeated, to the best of my ability, for the benefit of my companion[26] on the daily four-mile walk between Cambridge and our Brookline home. So sure was I that all the statements were correct and all the conclusions sound that any doubts or criticisms upon the part of my acute and unprejudiced friend shocked me as a reprehensible compound of heresy and *lèse majesté*.

From the fall of 1866 until, mainly upon his recommendation, my connection with Cornell University, I was employed in making preparations to illustrate the structure of sharks and rays for his projected volume upon those fishes.[27] This work brought me into relations with him, more and more close, instructive and delightful. From my diaries and letters are selected a few incidents exemplifying phases of his nature not generally appreciated.

Speaking of Darwin, whose doctrines he vehemently opposed, he remarked: "Much as we disagree, we are truly friends."

With some earlier assistants there had been a serious disagreement ending in temporary estrangement;[28] yet when their names were mentioned before him he made no adverse comment. He once showed me a letter from one of them asking permission to examine certain specimens at the museum. Upon my remarking that the presence of that man might not be very pleasant for him he replied, almost with reproof, "It is true that I have built up this museum, but I am only its trustee, and if the devil himself wished to study here he should be welcome."

His tenderness is shown in the following incident. The artist who was drawing the plates for the volume upon sharks and rays above mentioned was an elderly German who, uncertain of the term of his employment, had left his family in St. Louis. At last, in his loneliness, he sent for one of his children, a lad of ten. Supplied with credentials of various kinds, the boy reached Cambridge and inquired for "Herr Professor." It was after dark and Agassiz sorely needed rest after a long day at the museum. Yet, instead of summoning a servant, he took the child by the hand, walked with him several squares, and delivered him safe to the anxious father.

The summer of 1867 I spent literally at his side in the laboratory adjoining his summer home at Nahant. Together we dissected the sharks and rays that were brought in by the fishermen. To the paraphrase, "No naturalist is a hero to his laboratory assistant," he was

[26] James Herbert Morse, Harvard, '63.

[27] See his report as director of the Museum of Comparative Zoology for 1867, p. 10.

[28] The full merits of the case may never be understood, and this is not the place for its discussion; but in the light of my own experience with him, on the one hand, and with my pupils and assistants, on the other, I incline toward his view of it.

an exception. For me that summer was a scientific idyl. That the pleasures of my memory of it are less than perfect is due to my later realization of how inadequately I appreciated my privileges and opportunities. Three specifications in the general charge of my unworthiness will serve to set his own tact and delicacy in a clearer light.

A fisherman brought a hammer-head shark. Although familiar with pictures of its rather strange form, I had never seen a specimen, and expressed my interest somewhat exuberantly. The man named a certain price, and Agassiz paid it. When he had gone, Agassiz said to me seriously, but with no shade of rebuke: "This shark is not so very rare, but your outspoken surprise led the man to ask about twice what it was really worth." After that I would have held my peace in the presence of the "sea-serpent."

Agassiz was paying me one dollar per hour, an arrangement convenient for both, especially in the summer. I wished to learn stenography, and studied that early in the day, going to him about nine o'clock. One hot July morning I found him grieving over the rapid deterioration of some specimens that had been brought in at daybreak. I explained the cause of my delay, and added that, but for the necessity of earning my living, I would gladly work for him all the time and for nothing, in return for what I learned from him. "Ah," he said, "I hoped you felt so, but I was not sure. Now we are like lovers after the important word has been spoken." Not for all the short-hand systems ever devised would I lose the memory of those words and of the look that accompanied them.

In those days (it was forty years ago) it might fairly be said that about the brain, zoologists knew little and cared less. No one of my teachers had made a special study of either its structure or its functions.[29] That summer, however, Agassiz studied the brains of sharks and rays, exposing them by "whittling" the cartilaginous skulls with a jack-knife given him by Longfellow (who, by the way, made a visit to the laboratory). He compared the various forms with the only published plate we had (that of Dumeril), and would sit poring over them by the hour. Occasionally he would show them to me, and ask if I would not like to work at them. (Remember that he was paying me out of his own pocket and was entitled to assign all the subjects.) No, I had started upon some other parts of the anatomy, and was indifferent. That is too mild a term; I must have been a compound of a mole and a mule. He sighed and gave it up. That I then made the mistake of my life I did not perceive until years afterward, too late to repair the loss. Now, by way of atonement, I in-

[29] In 1844 and 1845 Agassiz published two short papers upon the brains of fishes; in "A Journey in Brazil," p. 244, note, he deplores the loss, in a storm, of a lot of brain preparations in a cask that had been left on deck. In the last but one of the twenty lectures given at Cornell University, he said, "The brain is the organ that determines the rank of animals."

sist that the objective study of the brain should begin in the primary school,[30] and I look forward—however undeservedly—to the period when no other subject need claim my attention. At times, however, I speculate as to what part of the nether world is paved with ignored advice and neglected opportunities.

His helpful attitude toward prospective teachers was exhibited in the following incidents. After my appointment to Cornell University in October, 1867, he arranged for me to give at the Museum a course of six "University Lectures," and warned me to prepare for them carefully because he should give me a "raking down." He attended them all (at what interruption of his own work I realize better now) and discussed them and my methods very frankly with me.

A year later, while at Ithaca, he attended several of my lectures upon physiology, although they broke up his forenoons and the subject did not interest him particularly. After one he expressed his approval of its simplicity and the absence of hifalutin,[31] and advised me to counteract the effect of lecturing by investigation. Another lecture dealt with the structure and functions of the heart, for the illustration of which we had excellent charts and models although not, at that time, any actual specimens. I believed that I had done very well, and accompanied him down the hill toward his hotel in the hope that he would say something complimentary. All he said was, "After lecturing upon a subject I have found it a good plan to go to work and study it some more." Then he began to talk of the glacial scratches upon a big rock that we passed. The justice of his criticism was equal to the delicacy of its conveyance.

The work done by me here in 1871–3 upon the brains and embryos of domesticated animals has been referred to already as one of the indirect benefits conferred by Agassiz upon this university. His satisfaction with the results evidently led him to make a most honorable overture and invitation. On the seventeenth of November, 1872, he wrote a letter beginning: "I wish I could have you permanently in Cambridge as professor in connection with the Museum and the University. The first thing to know is whether such a plan would suit you and under what conditions you could accept a proposition, etc." The matter was discussed at more length in letters dated December 7, 1872, and September 10, 1873. It has never been mentioned before by me, but there seems to be no longer reason for reticence.

The second letter contained also the invitation to be one of the instructors at the summer school already mentioned on p. 12. He

[30] Upon this point see my papers in *Science*, December 17, 1897, p. 903, and May 26, 1905, p. 814.

[31] This, the only approach to slang that I recall from his lips, doubtless referred to my introduction of a somewhat far-fetched quotation from Shakespeare in an address before the Harvard Natural History Society, reproduced in the *American Naturalist*, Vol. I., p. 421; it was my first and last transgression of the kind.

wrote: "Among my plans is a course of practical instruction in Natural History at the seashore, during the summer months, chiefly with the view of preparing teachers to introduce Natural History into our schools. . . ."

In the two cases just mentioned it may be said that the advantage was mutual although mine much more than his. But in the following instance his words and deeds can bear no other interpretation than disinterested willingness to aid another at his own inconvenience.

In preparing for a course of lectures before the Lowell Institute I wished to dissect the limbs of certain rare animals which we could neither collect nor afford to buy. On making my wants known to him he promptly took a knife, went with me to the museum store-rooms, and with his own hands cut an arm and a leg from each of several precious specimens. In thanking him I said I had reason to believe that the invitation to give the course was due largely to his having taken the trouble to commend me to the curator; and that I wished he would let me make return by doing some work for him without compensation. He replied, emphatically, "I could not think of it; it is my business to help young men."

In Agassiz were combined five qualities, not uncommon singly or even by twos and threes, but rarely so completely united or so highly developed in one personality, *viz.*, attractiveness, eloquence, strength, energy and helpfulness. As distinguished from Napoleon, from Bismarck, from Goethe, and even from Washington and Abraham Lincoln, Agassiz was at once fascinating, persuasive, powerful, active and uplifting. Under my personal observation have come but two others comparable with him in this most potent combination of great qualities, *viz.*, Henry Ward Beecher and Phillips Brooks. They were preachers; so was he. They based their ministrations upon what they regarded as the Word of God; he drew his texts from what, with equal faith, he held to be the works of a Divine Creator. They were also alike in this; never was voice or hand raised otherwise than for the betterment of mankind.

On returning from Penikese in the fall of 1873 I went to the museum to arrange some specimens, when he came in and reproached me for not letting him know I was there. I explained that I knew he was tired and ill and that I would not take his time. He replied, "Doctor, you are always kind," and those last words have been treasured as a benediction. This coming fifth of September it will be thirty-four years since I beheld my teacher, friend and benefactor in the flesh, but in my mind's eye his image will never fade. Take him for all in all I ne'er shall look upon his like again. Would that it might be justly said of all great men, as I now say of Agassiz: The sun shone brighter at his birth, and shadowed when he died.

# NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE

By FRED DeLAND

PITTSBURGH, PA.

## X. Early Aerial Telephone Cables

PROBABLY John I. Sabin was the first telephone man to use an aerial cable. In connecting his line in San Francisco in 1879, he did not run his circuits into a cupola, as was then the fashion, but employed several lengths of a special cable made by Eugene F. Phillips, of Providence. This cable was composed of forty No. 20 soft drawn copper wires, double braided with cotton, then double wrapped in reverse order with rubber paper, the whole being wound with a cotton or jute covering. It cost 20 cents a foot at the factory. It was suspended by using long canvas slings about two feet apart and attached to two heavy iron wires.

In referring to the growth in overhead circuits, Mr. Phillips stated that:

> The natural increase in the number of aerial wires created a demand for better insulation and grouping in cables. Hundreds of miles of No. 12 iron wire were braided and dipped in suitable compound for this use. The annoyance from induction soon made a call for anti-induction cable. This want was supplied by a tin-foil cable so called, in which each conductor, after being insulated, was enclosed in a strip of this tin-foil. Cotton-covered wires to the extent of 50 or 100 were cabled together, and after being saturated with paraffine were placed in a lead pipe. This style of aerial cable, although quite satisfactory, has to a great extent been replaced by the paper-insulation underground cable of the present day.

Aerial cables were in use in New York City late in 1879, and before the close of 1880 a total of over 75,000 feet was in use in the city and on the Brooklyn Bridge, principally of ten-conductor capacity. In September, 1880, C. E. Chinnock told the delegates to the first telephone convention:

> We have over the East River bridge at the present time, four cables, 3,800 feet long, each cable with seven conductors. These cables have taken the place of cables that were previously there with the ordinary kerite and gutta-percha insulation. In using the cables and talking on one wire, you could hear whatever was said on another wire, and by wrapping each conductor with lead and grounding at intervals, all of the escape and all induction were completely eliminated. These cables have been in use, two of them for six months, and one for nine months, and are now working perfectly.

In May, 1880, W. D. Sargent used a lead-covered aerial cable to connect two exchanges in Philadelphia. This cable was made by David Brooks, Jr., son of the inventor of the Brooks cable. It was

composed of 42 twisted pairs of No. 18 cotton-covered wires, which were wrapped together and drawn into a lead pipe one inch in diameter. Then a mixture of melted paraffine and rosin was poured into the pipe, the whole forming a solid mass on cooling. This cable was about 600 feet in length and was suspended from three heavy iron wires by loops made of No. 14 iron wire.

At one of the telephone conventions C. N. Fay stated that

> the use of cables for telephone purposes in Chicago began in 1879, when a 50-wire Brooks oil-pipe cable, 925 feet long, was placed in the Washington Street tunnel under the bed of the Chicago River. The conductors were made of No. 20 copper wire, insulated with cotton, and drawn through an iron gas-pipe previously polished smooth on the inside. The ends of the pipe were elevated, and upon each end was placed a reservoir capable of holding three or four gallons of paraffine oil. After the pipe was put in place, the cable was drawn through. Paraffine oil was then poured into the reservoirs until the pipe was filled from end to end and both reservoirs were full, when the caps were screwed on and the whole made tight. There was a loss of oil from evaporation and leakage through the pipe, requiring a refilling about once in six months. In 1880, a 75-pair cable of similar construction, 450 feet long, was placed in the LaSalle Street tunnel under the Chicago River; another one being placed in the spring of 1881. In 1884, all the oil-pipe cables were in good and satisfactory working condition. . . . The first aerial cable was put up in Chicago in September, 1882, and was a 50-pair Patterson cable 1,350 feet long.

Six Brooks oil-pipe cables were in use early in 1880 in Milwaukee. Each cable was about five hundred feet in length and composed of fifty single conductors, and all were considered "very satisfactory."

It is of historical interest to note that in April, 1843, S. F. B. Morse detailed to the Secretary of the Treasury the specifications under which forty miles of a four-conductor lead-covered cable would be made. Each wire was to be

> once covered with cotton thread, to receive two coatings of shellac varnish; then wound with a different colored twine to designate, in case of necessity, any particular wire in any part of the course. The four lengths are then laid side by side and bound together in a single cord by another winding of cotton twine. The conductors thus prepared are ready to be introduced into the lead pipe.

## XI. Forcing Telephone Wires Underground

When the underground question first came up, the leading telephone companies made it clear to the authorities of the respective municipalities, that any hesitancy in removing overhead wires and placing them underground was not due to an unwillingness to make the additional and very large investment necessary, but to contending with obstacles that then appeared insurmountable. There was no practical underground system suitable for telephone distribution in American cities. Several experimental systems were being promoted, but all appeared to possess little practical value. One promoter laid a half-mile of his pipe underground and then invited a large number of telephone, tele-

graph and electric-light men to thoroughly inspect the condition of pipes and wires. Following this inspection came a banquet of nine courses, at which eight different wines were served to more than a hundred guests. Referring to proposed drastic legislative action to force the wires underground, David Brooks wrote on March 13, 1882:

> I have every reason to believe that the great quantity of poles and wires that are now so objectionable in our streets may be dispensed with in the future, and while the company is so earnestly engaged in testing this problem of underground wires, I can see no good result to be obtained by the passage of these bills. It will be to their interest to make an underground system whenever it is practicable.

The attitude of the parent Bell company on the underground question is shown in President Forbes' annual report dated March 18, 1882, in which he states that

> our experiments in underground cables, while not as successful as we had hoped, have given sufficient promise of satisfactory results to warrant us in undertaking at considerable expense to test the different methods. With this object, we have asked permission to put down cables in Boston, and, as soon as the needed consent is obtained, we propose to make careful and thorough practical tests of the best systems offered. . . . The cost of replacing an extensive overhead system in a large city is so serious that it can not be hastily decided upon; yet, if the wires can be laid underground and made to work rightly, at a cost which will not be prohibitory, it is hoped that the service will be better than now, and the cost of operating less than by overhead wires.

The first Morse telegraph patent of June 20, 1840, refers to the wires being laid underground, and a portion of his first telegraph line was buried, but proved inoperative, while on a section built with the aid of cattle-horns used to support the line on and insulate it from a stone viaduct, good service was secured. But the first American patent for underground lines was issued in 1869, and it was the only one issued until 1873, when two more were issued. A total of twenty-one patents were issued prior to 1880, when, in that year, seventeen were issued, and twenty-eight in 1881. Aerial as well as underground conduits, evidently based on the old Graves method of 1858, or the Carter of 1875, were also suggested as a remedy for the multiplicity of overhead wires, and elaborate systems supported upon iron posts or columns erected either on one side of a street or overarching the roadway and supporting the wires in the center were made, upon paper, to appear very attractive, and earnestly advocated as a practical public improvement. In fact, the opinion was expressed at the third telephone convention held at Saratoga Springs, that

> with a light and ornamental aerial cable support the requirements of the public could be satisfied and the introduction of subterranean wires obviated entirely or confined wholly to important trunk routes. . . . The Scott elevated wire-way system consists of cupolas located upon housetops, separated at any convenient distance and connected by a suitable tube, through which wires to the number of two or three hundred are drawn and properly connected at the cupolas. The

tube is preferably made of rubber and braided fabric upon a spiral foundation of wire, by which the tube retains its circular form. The tube is suspended from a supporting wire of sufficient strength to stand the strain of severe wind and the weight of accumulated ice and snow. The wires, which may be either well insulated or even the ordinary braided or double-wound wire, can be drawn in singly or in groups and connections made at the cupolas. The tube, being impervious to moisture, the channel inside will remain perfectly dry. Since the last report of the committee, it has been introduced on a limited scale in the city of Boston and it will soon be extended.

While no underground system satisfactory to telephone men was available in 1880–3, a few wires had been laid underground and some experience of an expensive character gained. For instance, the Western Union carried out some costly experiments with underground wires in New York City during the four years, 1876–80. In 1876, two 4-inch iron pipes were laid from the main office to Pier 18, a distance of one third of a mile. In each pipe

was placed a cable of sixty conductors, the wires insulated with gutta-percha, and wound separately with a layer of tarred tape, the whole covered with a double layer of heavy tape tarred and run through sand to prevent sticking to the pipes.

These cables were connected to the submarine cables running to Jersey City. In 1876, a 12-conductor cable about 2,200 feet in length was laid between the main office, 195 Broadway, and the branch office on Broad Street. Owing to the proximity of steam pipes and the destructive effect of gas on the insulation, these cables were short-lived. In 1880, a new 28-conductor cable was laid between the same offices. Before the end of 1882, eleven of the conductors were useless. In May, 1882, sixty circuits were laid between 195 Broadway and 134 Pearl Street, only to be abandoned within a year, every circuit having failed within seven months. On November 28, 1888, it was stated that the result of the Western Union

experiments during the past twelve years proves that there is no form of underground cable and conduit which can be depended upon to give more than four or five years' service under the most favorable circumstances.

In 1878, John P. Barrett, superintendent of the city telegraph system, placed the fire-alarm and police signal wires underground for a distance of 840 feet on a handsome residence street in Chicago. Two-inch iron pipe, the interior of which was heavily coated with tar, was laid underground and into this pipe two kerite insulated wires were drawn. Ten years later it was stated that these wires had given no trouble and were in 'practically as good a condition to-day as when so placed.'

Submarine telegraph cables were in use thirty years before the first telephone exchange was opened. Referring to the first one used in this country, Henry A. Reed said:

This cable was of No. 9 iron wire, insulated to the thickness of half an inch and was made in 1847 by Stephen Armstrong in Brooklyn, N. Y. It was laid

across the North River at about Fort Lee. It only worked a few days when it was dragged out of place by a ship's anchor. The first iron-armored cable was made by S. C. Bishop in 1852, and was used across the North River, above Cold Spring. This cable was of No. 14 copper wire with an insulation the size of No. 0, protected by jute and armored with iron wire about No. 8.

Submarine telephone cables were used in 1879 by several companies in crossing rivers and bays, notably in Chicago and Milwaukee, and Patterson telephone cables were placed in the Washington Street tunnel crossing under the Chicago River, in 1879, as previously stated. But probably the first telephone cables that formed a part of a regular underground system were laid in Pittsburg in 1881, by Henry Metzger. Three lead-covered cables were laid on Fifth Avenue between the exchange and a distributing pole, about a thousand feet distant. The cables were composed of 50 single conductors of No. 26 copper wire, and were placed in a wooden box, 6 x 8 inches, made of one-inch plank, that was then filled with asphalt and laid inside the curb below the frost line. No manholes were used, but connecting wires were spliced with a T-joint. In June, 1882, Mr. Metzger laid eight more Patterson cables underground, the longest being 2,200 feet in length, composed of No. 18 B. & S. single copper wires. These cables gave good service for a number of years. That same year, 1882, the New England Telephone and Telegraph Company laid two Patterson 50-pair cables in Boston, for metallic circuit service. The lead-covered cables were drawn in iron pipes laid in cement. One cable was 1,200 feet and the other 1,485 feet in length; both were composed of No. 22 wire, cotton covered. One was laid in Pearl Street in October, the other in Franklin Street in November, 1882.

On May 20, 1882, Professor Chas. R. Cross, in considering the various electrical problems involved in the introduction of underground telephone cables wrote:

> In the first place it should be remembered that the number of wires in foreign cities is probably not more than one fifth as great as in American cities of equal size. Thus in Bruges, Belgium, a city of 50,000 inhabitants, there is but one telegraph office, that at the railway station; in Ghent, with 120,000 inhabitants, there is but one telegraph office; in Antwerp, with its enormous commerce, there are but two, one being at the railway station; and in Brussels proper, only one office except at the railroad stations.
>
> In London and Paris almost all messages are sent from the outlying offices to the central telegraph office by means of pneumatic tubes, and the telegraphic despatches sent from there. From these facts it will be seen that the absolute number of underground wires in foreign cities is much less than is popularly supposed. Contrast in this respect Boston and suburbs, with 377,000 inhabitants and forty-nine telegraph offices, and Brussels and suburbs with 315,000 inhabitants, and eight or at most ten offices.

In April, 1882, thirty-eight sections of a lead-encased telephone cable were laid underground between the two tracks of the Boston & Providence Railroad extending from the depot in Attleboro to West

Mansfield, a distance of about five miles. The cable was made by Eugene F. Phillips in sections of five hundred and thirty feet, and connected by means of junction boxes, and he gave the readers of the *Electrical World* (March 4, 1899), an interesting account of the manner in which the cable was laid. In part, Mr. Phillips said:

> In 1882 the American Bell Telephone Company, wishing to make some practical experiments on telephonic transmission with underground wires, ordered of us a cable to be 5 miles in length, containing twenty-one wires of No. 20 B. & S. gauge, a majority of which were to be insulated with rubber and the balance braided with cotton and paraffined; part of the conductors to be covered with tinfoil, and part twisted in pairs for metallic circuit; also a single conductor of No. 13 B. & S. gauge braided and paraffined. We believe this was the first underground experiment made for the American Bell Telephone Company, and the laying of this cable was a red letter day for us. The American Bell sent an engine and one open-end freight box car, which carried the 5 miles of cable we had already made to Attleboro, as well as fifty men for a working force. In laying this cable a trench was started by means of pick and shovel, but it was soon found the hard roadbed was by no means easy digging. A plow was borrowed of one of the farmers and attached to the outrigger from the truck of a car, pulled by an engine. As we were unable to hire oxen or horses to plow with, this idea was suggested by W. H. Sawyer, and it made a fine specimen of plowing, the like of which was probably never before witnessed. When the trench was completed, two plows had actually been consumed in the process. The cable was placed at the end of the car and paid out into the trench as the car moved along, and close behind the plow in the furrow. The filling of the trench was also another great conundrum; the gang started with shovels and hoes to do this, but it at once became evident that it would be a week's work with the force at command. Again Sawyer's inventive genius came to the rescue. At his suggestion a joist was procured, and one end lashed to the cowcatcher of the engine, the other end extending out over the trench on the side where the dirt had been thrown. The engine was started, and the entire length of the trench and cable was soon covered, much to the pleasure and satisfaction of those looking on as well as those responsible for the filling.

Notwithstanding that prior to 1890 no underground system proved satisfactory from a telephone engineer's point of view, yet the rapidity with which the telephone companies responded to the public demand that the wires be placed underground is apparent from the fact that while the underground movement started in 1881, at the close of 1884 there were 1,225 miles of wire underground, and ten years after the first telephone cables were placed underground, over 70,000 miles of wires were in subterranean ducts. To-day over one half of the total mileage of telephone circuits in use by Bell subscribers is underground, that is, nearly three million miles of copper wire are buried in the earth.

## XII. The Effect of Electric Street Lighting on Telephone Service

While an inability to dispose of the securities of the local companies retarded the growth in subscribers in many exchanges, in 1883–5, other causes were also hindering the expansion of the telephone in-

dustry. One cause was the rapid introduction of electric-light circuits, so poorly insulated as to sadly interfere with good telephone service and necessitating the rearrangement or reconstruction of many telephone circuits. As already stated, the first street lighting occurred in Cleveland in April, 1879, with Brush arc lamps. In San Francisco the Western Electric Light Company was organized by G. S. Ladd, and on February 6, 1879, was supplying current for private service according to *The Bulletin,* which said:

**Yesterday the Western Electric Light Company made connection with the Gold & Stock Telegraph Company, and now all the electricity used in running their stock indicators throughout the city is supplied from the Gramme machines, thus doing away with five hundred cups, which heretofore composed their battery.**

It is stated that arc lamps were in service in San Francisco in October, 1879, the rate then charged being $10 a week when burning from dark till midnight.

It was fortunate for the continued broadening of the telephone industry that it got a strong foothold before the parent electric-light companies began to devote their energies to belittling each others machinery and motives, or to determine whether it was wiser "to advocate the use of sixteen small single light arc machines, with their costly system of conductors, or one sixteen-light arc dynamo," instead of perfecting the insulation on pole line circuits, even if they did not increase the efficiency of their apparatus. Otherwise the electric transmission of speech might have had a different growth recorded. For the character of the crude and cheap telephone construction prevalent in 1878–80 would not have been tolerated by the public in 1882–3, by reason of the number of violent deaths resulting from accidental contact with live wires, deplorable accidents that started a rabid agitation in favor of placing all wires underground. No underground system suitable for telephone circuits was then in existence, and had one been available, the heavy initial cost of installation would probably have deterred many investors from entering the telephone field under such unpromising conditions.

In New York state alone more than a hundred electric-lighting companies, having an average authorized capitalization exceeding a million dollars each, were incorporated before the close of 1883. And as the electric lighting industry was raw and untried, as suitable or even satisfactory line insulation had yet to be devised and tested, and as competition among electric-light companies in many sections was destructively fierce, it is needless to say that the unsafe construction of the average competing electric-light company was such a menace to the satisfactory continuity of telephone service that telephone managers were compelled to forego making verbal or written indignant protests, and to devote every moment of time to devising methods and means for protecting their equipment from the

destructive effects of stray currents. Even then, imperfect protection resulted in the complete or partial destruction of several telephone exchanges. Following the destruction of one exchange, Mr. A. S. Hibbard suggested that in view of the delay in getting large switchboards in emergencies, it would be a wise thing in the way of insurance, if a number of telephone companies would jointly buy a complete central office equipment, to be built and held in convenient storage, with the understanding that it should go to the first company whose exchange was burned, and that that company would pay its cost price or replace it with new equipment.

Referring to the introduction of electric-light circuits, Mr. W. J. Denver told the members of the Boston Electric Club:

> I remember the first time the arc lights were exhibited in my native city, and what a tumult was caused at the telephone office. An electric light circuit was strung, using the ground for a return and four or five lights were placed upon it. Immediately on the starting of the dynamo, up went the lights and down went the switchboard drops, and the confusion of tongues consequent upon the building of the tower of Babel was as the stillness of death compared to the racket on the telephone wires. . . . The remedy was evident; double the light circuit, which was done the next day.

When the electric-light industry started, the electric lighting fraternity turned to the telegraphers for assistance and advice, just as the telephone men did. But the electric-light men also had the advantage of the experience gained by telephone men in building local circuits. It is written that the first electric-light switching devices were derived from the telegraph switch, only enlarged to accommodate the greater volume of current. The strap key, the telegraph key and the switchboard plug were all utilized in central-station electric lighting, and the arc that formed between the terminals following the withdrawal of the plugs was usually blown out with the breath, or whipped out with a cloth, or extinguished with a handful of sand.

In other words, the same degree of crudeness was just as strongly in evidence in primitive electric-light plants as in the pioneer telephone exchanges. And, as one writer stated it in 1882,

> there are electric-light charlatans as well as medical quacks, charlatans totally ignorant of the electrical laws, and with no experience in electric lighting.

One point worthy of note is that the telephone engineer soon found that he must not only be able to solve telephone problems, but must also be thoroughly conversant with every phase of electric lighting, and then of electric power and of electric traction that was in any manner likely to have a bearing on or to influence the character of telephone service. Thus, as the editor of *The Electrical World* has so concisely stated:

> In the telephonic engineering done by Carty and his colleagues there is no parallel whatsoever to be found in any other branch of electrical engineering.

# THE GREAT JAPANESE VOLCANO ASO

By ROBERT ANDERSON
WASHINGTON, D. C.

ASO-SAN, or Mount Aso, is a living volcano in the heart of the island Kiushiu, Japan, whose peaks rise to a height of several thousand feet out of a gigantic bowl. This bowl, which is many miles across, is an ancient crater surpassing in size all other known craters nearer than the moon. Some 5,000 people, grouped in half a hundred villages on the old floor, are living to-day, tilling the volcanic soil and trading in this vast crater, round about the base of the new and ever-active cone that has risen in it.

Kiushiu is the most southern of the four main islands in the Japanese archipelago. It is about 17,000 square miles in extent and is therefore larger than Vancouver Island, or almost equal in area to Massachusetts and New Hampshire combined. It is built up of very ancient rocks, both sedimentary and igneous, belonging to the paleozoic and mesozoic eras, as well as of younger rocks, and upon these as a foundation has been erected in more recent times, partly during the age of man, a superstructure of volcanic materials which now covers many thousand square miles, or about one half the area of the island. It contains twenty volcanoes, counting two that are just off the coast to the south, of which eight are now active. Among them Aso-san is on far the largest scale, though now it is in a decadent stage and is surpassed in activity by two or more of the others. Japan through all past ages has been a land of extraordinary geological activity, possessed of a vital energy which, continuing in force up to modern times, has been emphasized by the changes in level of its coasts and heralded by its ever-vigorous volcanoes. It is far from being a land solely of volcanoes and volcanic formations, as is sometimes thought, for these assume insignificance when compared with the wide areas and great thicknesses of strata that are representative of almost every stage of the geological column. But that it is a country of great volcanoes there can be no doubt. They have flourished ever since the beginning of its geological history and to-day there are 164 independent volcanic cones, or colonies of related cones, scattered through the Japanese islands, including the Kuriles and the Liu Kiu chains. Of this number 54 are now actively grumbling and nursing their wrath and occasionally losing all control. Fuji-san and Aso-san are the kings, although others surpass them in destructive activity. The first is famed for the height and regularity of its cone as one among the preeminently symmetrical and beautiful volcanoes of the

world. The other is almost unknown except among the Japanese, although its immense crater is the largest of all that have yet been found on this globe.

The center of Kiushiu is about 600 miles distant from Yokohama and Tokio by the ordinary routes of travel, and by far the best way to reach Aso-san is from Nagasaki, whence one of two routes may be followed—either far around from the peninsula on which Nagasaki is situated, a distance of 150 miles by railroad to Kumamoto, a city on the west coast of Kiushiu, within 25 miles of the volcano, or most of the way by sea, a distance of 75 miles to the same city.

The pilgrim or traveler who mounts to the walls of the castle of Kumamoto and looks eastward over the green and gardened city and over the rich plain bordering the bay of Shimabara, off to the mountains that form the backbone of the island, sees the massive, sacred, god-mountain Aso above a long blue chain. A thrill passes through him as he sees a white cloud streamer waft horizontally across the grey clouds around the summit or, rolling into a ball, float upward like a thistle-down. The white cloud is soon dissipated, but another born from the mountain takes its place as soon, and one knows that here is a volcano, that the god of the mountain is alive. Hundreds of Japanese visit Aso-san every year to pay their homage to the deity that the mountain represents, but only rarely has it been visited by foreigners.[1]

During the spring of 1905 the writer and his brother, Malcolm Anderson, and their friend, Kiyoshi Kanai, spent several weeks in the vicinity of Aso-san, staying for many days in one of the villages in the old crater, living in native Japanese fashion and coming in touch with the spirit of the people and the natural history of the region. The way from the west coast to the mountain lies across the Kumamoto plain among little open fields that in the spring are richly colored with deep green wheat and yellow mustard, along a broad avenue eighty feet wide marshaled by stately cryptomeria trees whose handsome bark and foliage remind one of their big cousins—the California redwoods. Beyond the village of Seta at the edge of the lowland, some 13 miles from Kumamoto, one is led up into the mountains by a gentle ascent, the volcano itself being all this time hidden by the intervening slopes. But a backward view reveals the lesser volcano Kimbo-san rising as an independent cone near the sea, and if the day affords one of the clear Japanese skies, which unfortunately are only too rare but which are so beautiful when they come, one sees the

[1] The only mention of Aso and its crater that the writer knows of is in an article by the geologist, John Milne, in *The Popular Science Review*, New Series, Vol. IV., No. 16, October, 1880, and in Murray's 'Handbook for Japan,' by Chamberlain and Mason. The former is an English periodical that has long since ceased publication.

great destructive volcano Unzen-dake springing up to nearly 5,000 feet on the peninsula of Shimabara over across the gulf. One travels to Aso-san as one chooses, either on foot, in a jinrikisha, or in the funny little perambulating dry-goods box known as a *basha,* the Japanese adaptation of the English stagecoach. We preferred to walk, and upon leaving the plain we enjoyed many picturesque miles up the cascading stream Shirakawa. For the first night out from Kumamoto we stopped at a modest little inn, being driven by a pouring rain to take shelter at the hamlet of Tateno, which is perched high up on the side of the canyon that the road follows, at an elevation of about 1,200 feet above the sea. From there on the canyon of the Shirakawa becomes more precipitous in outline, and a short tramp in the early morning along the mountain slopes above it brought us to its brink at a point where it forked and cut squarely across our path. Here, pillared walls formed of roughly columnar lava, through which the stream has cut a grand gorge, drop sheer several hundred feet, and the path descends a zigzag course to their foot, where the two forks toss into one stream over a boulder-strewn bed. Near here a hot saline spring surrounded by the hamlet of Tochinoki, where many bathers come, give the first evidence of the proximity of the volcanic center.

Whichever of the two forking streams one follows, one presently comes up upon a broad plain that is surrounded by heights on every side and that curves around in the form of a great crescent. But, instead of ordinary mountains, the outer convex curve of the crescent is ringed about with an even-topped wall rising on the average about 1,500 feet, while the concave side is bordered by a great rugged mountain mass attaining a height of over 4,000 feet above the plain. The configuration of the region is absolutely unique and one is at a loss to understand its significance until later on, climbing the mountains and gaining expansive views over the whole broad domain of Aso. The truth is this: That a vast oval crater basin occupies the region, but is divided in two by a range of mountains that has risen across its center diametrically. The two portions of the crater thus cut off are the two crescent-shaped plains, whose level bottoms are formed by the old crater floor, whose outer surrounding walls are its rim, while the inner side of each is walled in by the great dividing range. There is but one opening in the ramparts hemming in these basins. It is where the western end of the central range meets the bounding wall. Each of the two halves of the crater is drained by a stream, and these small rivers uniting around the base of the central range at this western end, flow through the common outlet—the grand gateway through which we made our entrance. It is 10 miles across the crater from west to east in the diameter occupied by the dividing mountain ridge, while from wall to wall from south to north it is 14 miles. These figures, it must be stated, are only estimates, but a

number have agreed that they are approximately correct. The oval area occupied by this volcanic bowl is thus over 100 square miles, an area half as large again as the District of Columbia.

The crater of Aso is both for size and structure unique among the craters of the world. The Hawaiian volcanoes, with which Aso shows the most resemblance, are of greater bulk, but their craters, which are usually spoken of as the largest in the world, can not compare in size with that of Aso. The crater of Haleakala, according to Dana, is 7½ by 2¼ miles in dimensions, and covers some 16 square miles. It has a greatest depth of 2,500 feet. The Kilauea crater, Dutton gives as 3½ miles long by 2½ miles wide and from 300 to 700 feet deep. The crater of Mauna Loa was measured by Alexander as 3½ by 1¾ miles in dimensions, with an area of 3½ square miles. The islands of Santorin south of Greece in the Mediterranean preserve the remains of a crater 18 miles in circumference, and Pantellaria, between Sicily and Africa, one with dimensions of 8 miles by 6. The two Italian crater lakes, Bolsena and Bracciano, are of great size; the one is oval with a long diameter of 9 and a short diameter of 7½ miles, and the other is a circle 6 miles wide. The crater of the volcano Palandökan in Armenia is said by Bonney to be 6 miles in width. Among the volcanoes of the Canary Islands, Scrope mentions the cirque of Teneriffe, which contains a pit 2,000 feet deep and a high peak within it, as being 8 miles long by 6 miles wide, and Bonney the crater on the island of Palma as 9 miles in diameter. A crater on Mauritius is said by Dana to have a longest diameter of 13 miles. Among the great volcanoes of Java, according to Scrope, Papandyang has a crater with measurements of 15 by 6 miles, and Bromo one with diameter of 4 or 5 miles. Crater Lake in Oregon, described by Diller, is one of the most perfect. This nearly round pit is 4 or 5 by 6 miles in dimensions and has a depth of 4,000 feet. But Aso surpasses them all, with a crater equaling 2 or 3 times the combined volumes of the three great Hawaiian craters mentioned.

The journey over the old floor in the midst of such novel surroundings is a unique and pleasing one, but the stupendousness of the scene comes over one more strongly when he looks down upon it later from above. Our little party chose the southern of the two forks and followed it up for mile after mile along its gentle upper course. The distances proved elusive. We looked across the plain to the wall on the other side and it was only a little way, but still as we went the goal seemed no nearer. The ascent from the point of outlet of the streams is at first rather steep. Within about a mile, however, the fork that we followed bursts off the level of the crater floor in a picturesque waterfall. It is called by the Japanese *Aigaeri,* or "trout-return," for beyond this the fish can ascend the stream no farther. The view upward to the mountains surrounding the plain on all sides is mag-

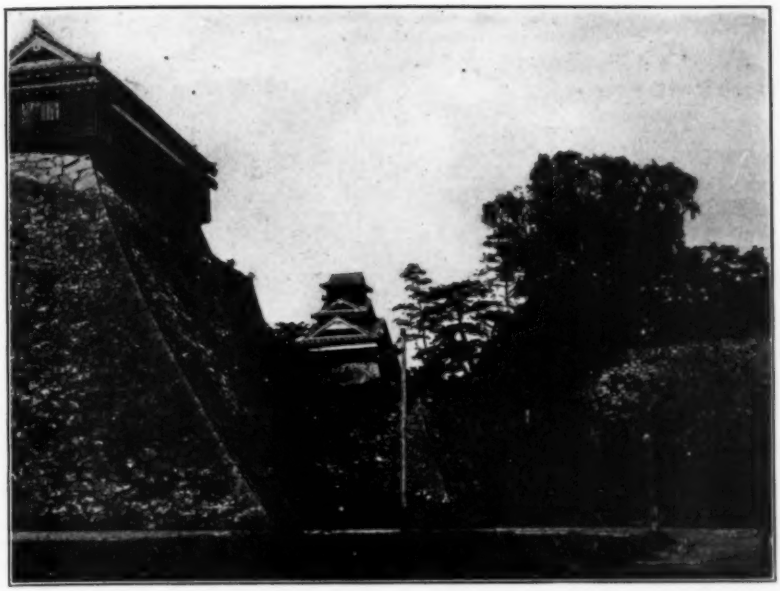

FIG. 1. THE CASTLE AT KUMAMOTO WITH ITS STRONG, UNCEMENTED MASONRY WALLS, BUILT THREE CENTURIES AGO. This style of construction requires a slope to the walls. The author and his brother ran a race to their top and found it quite possible to scale them. The superstructure of the castle was almost destroyed during the Satsuma rebellion in 1877. The view of Aso from the single remaining turret is magnificent.

FIG. 2. HOT SPRINGS AT YUNATANI NEAR THE WESTERN END OF THE ASO RANGE. There is a small geyser here that spouts out boiling water and red mud.

FIG. 3. PANORAMIC VIEW OF THE HIGHEST PORTION OF THE RANGE IN THE CENTER OF the highest peak of Aso-san. On the right is Neko-dake. Photo by Malcolm Anderson.

nificent as one journeys on over the gently rolling surface of the basin floor. To the southwest the ring wall, elsewhere comparatively level-topped, rises up into mountain peaks that are between 2,500 and 3,000 feet higher than the level of the plain. To the north and northeast run the mountains that form the barrier between the two halves of the crater. They make up one massive, rugged ridge whose summit is broken by several dominating peaks. It is this range or ridge that is named Aso-san. On the summit, but at the foot of the highest peaks, at a point about half way from end to end of the Aso ridge, is situated the modern active crater from which rose the cloud that we saw from Kumamoto. A view of the rising steam puffs is again obtained as one comes out into the widening plain above the waterfall. And as one goes farther and finally reaches the central and widest portion the view of the Aso range, which was at first an endwise one and eastward, opens out until one looks to the north upon it broadside. There are three main peaks and many minor ones, the most striking of them being Neko-dake at the farther, eastern end. Its slopes have the graceful curving outlines characteristic of volcanic cones, and its summit is a jagged battlement of monumental lava pinnacles looking somewhat as if they might be the remnants of a shattered crater. Its eastern flank drops down and ends the range by blending with the converging outer walls of the two basins. The next nearest peak is Taka-dake, a higher although less distinctive summit forming the culmination of the range. It is separated from

THE CRATER, looking north across the southern half of the crater. In the center is Taka-dake

Neko-dake by a depression of about 2,500 feet, out of which both mountains rise steeply. The ridge almost loses its continuity in this depression, so that Neko-dake is left as an isolated pyramid with truncated broken summit rising about 2,500 feet out of the highest part of the old crater to an elevation of 4,800 above the level of the sea. Taka-dake on the west side of the gap has an altitude of 5,600 feet above the sea, and is about 4,000 feet above the crater floor around its base, and some 4,500 feet higher than the point where the two streams have their outlet. On the southwest flank of Taka-dake rises the half-dome summit of a third peak, Naka-dake, facing the southern basin with vertical cliffs of black rock that have the appearance of being the cross section of a lava flow. It is from a low point of the range west of this summit that the steam cloud issues from the small modern crater, whose cone is hidden from the southern basin by an outstretched flank of Naka-dake. West of the new crater is another low place which divides the highest portion of Aso from the continuation westward. This gap is about equidistant from the two ends of the range. West of it rise subordinate peaks along the ridge, which gradually sinks lower until it comes to an end near the outlet of the streams. The distance from west to east across the big crater of Aso along the line occupied by the central range is about ten miles. But following the curving course of the crescent basin it is much farther from one side to the other. By the road through the middle of the plain the distance is about eighteen miles. Our little party after

passing through many hamlets and villages between long rows of small houses that line this main thoroughfare, at last, at a distance of twelve or thirteen miles from the stream outlet, reached Takamori which we had chosen as our goal. This is a prosperous small town with several hundred inhabitants, the chief center for the rich agricultural district hemmed within the volcanic heights of this southern half of the old crater.

This whole district is one wide expanse of cultivated fields, a mosaic of little patches differently planted, unfenced and unbounded, stretching freely down the plain in endless kaleidoscopic variety. In the spring-

FIG. 4. LOOKING SOUTHWEST ACROSS THE FLOOR OF THE SOUTHERN HALF OF THE ASO CRATER AT A MUCH WORN PORTION OF THE SURROUNDING WALL. The town of Takamori shows as a spot of white in the distance on the left. Photo by Malcolm Anderson.

time wheat and mustard, growing tall and vigorously, are the dominating crops, and the rich green of the grain mingled with the brilliant yellow of the mustard blossoms spreads a gay succession of tints over the wide plain. Here and there a tree, or a cluster or line of trees, for the most part dark pines or phantom bamboo groves, give a picturesque irregularity to the vast chess-board, standing like players on the light squares or the dark. The villages and groups of farm-homesteads with their conically roofed thatches appear as small as ant-hill colonies when viewed from above from one of the innumerable points of vantage round about, so small are they as compared with the breadth and depth and largeness of the scene of which they are a part.

On a day in April that dawned cloudless and with a frosty chill the writer set out to reach the summit of Neko-dake, the ragged-topped mountain at the eastern end of the Aso chain. As I went among the little fields and along the hedgerows in the early morning, always choosing among many paths one that seemed to lead me eastward, for beyond Takamori no well-beaten road continues farther up the plain, I met several people setting out also for the day. Each one of them looked with wonder at me, a stranger, staring with curiosity but bowing courteously in reply to a morning's greeting. One was a man with his faded bluish-grey kimono tucked up above his knees, leaving displayed a considerable expanse of underwear, his calves swaddled in blue-canvas walking gaiters above the straw sandals on his feet, and his shoulders wrapped in a bright red blanket—a man with the worn brown countenance of a country traveler shaded by a sun-darkened straw hat. He was a type of wayfarer often seen in the out-of-the-way portions of Japan, who, touched by an expanding arc of the great wave of westernization, has adopted a ludicrous cross between the native and foreign dress, a cross that possesses all the characteristics of degeneracy from both of the parent stocks. The next man that passed carried on his shoulder a short wooden steel-bound mattock or hoe, such as the peasants use in cultivating the fields, and another led a bull stout of neck and sullen of countenance laden with a rough plow and other tools for the day's work. These men were coming from their homes out to the particular little patches belonging to them somewhere in the plain. It is customary for the peasants to group their houses in small colonies and sometimes they go long distances to their work. Still another man, who came along the path empty-handed and empty-faced and out of work, was evidently quite resigned to the enforced leisure promising for that day. As I went farther and the day grew the fields became peopled here and there with men and women in small groups heartily beginning their task of digging and planting and nursing the ground. This is their daily occupation and so they live on peacefully, paying no heed to the filmy cloud floating over the crest of the Aso ridge, which now disperses before the spring sun only to return, in one form or another as a misty veil over the mountain top, a dark smoke, or a silvery cumulus cloud standing bright on the blue sky. There is no thought of the living force of the volcano.

The crater floor slopes upward from the outlet toward the east, and Takamori is several hundred feet higher than the level of the floor near the break in the walls where the streams flow out. It rises still more beyond Takamori and breaks from a fairly even plain into undulating hillocks which occupy the angle where the outer wall curving in converges with the Aso range. In this angle I reached the base of Neko-dake and the foot of the wall at the same time. The ascent was up a grass-grown ridge having an even slope of thirty degrees, but becoming

narrow and ragged as it approached the rocky mountain top. At an elevation of 4,750 feet by my barometer, just under the brow of the summit, I caught a glimpse on approaching of what I took to be a lonely wild cherry tree in blossom far up here alone. It proved to be a group of bushes with their bare limbs and twigs bearing little balls of snow, remnants of the winter.

From the mountain top a magnificent view opened and led me for the first time to a comprehension of the structure of the region. I had come from a deep basin on the south of the Aso range and here suddenly was spread out on the north its almost exact counterpart. At about 3,000 feet below the peak on which I stood lay this other far-reaching plain which seemed to be the continuation of the southern one, while round its outer edge it was enclosed by a similar curving wall. The grandeur of the scale upon which all the lines in the scène were drawn made the outlook a most impressive one, and with the view came a sense of the magnitude of the forces that had been at work in molding the large details of such a landscape. The sight was such that it carried with it at once the appreciation of these two huge bowls as parts of a great crater, divided by a high, massive mountain partition.

This crater is almost circular in appearance. Its rim forms a smooth sweeping curve around the whole circumference, broken only at the cleft on the west where the streams pass out, and on the east where it is joined by the slope of Neko-dake. The summit of this outer wall is remarkably even and its inner side precipitous. Although it presents rocky precipices at points on its face, its general slope is by no means perpendicular, but, being steeper as a rule than ordinary mountain slopes, it has a strikingly abrupt appearance. This is especially true in the case of the northern basin, where the wall facing the south is less gashed by lines of erosion, is more sheer, and has a more perfectly preserved even summit than the wall of the southern bowl. The latter wall is furrowed by gulches that have eaten back to the summit in places and notched the sky-line of the rim. Between these gulches sharp ridges run out into the plain, some of them looking more like lava flows descending from the wall than like remnants left by erosion. Such ridges run out into the northern basin as well, and little island-like hills rise in isolated positions from the crater floor. This half, though a close counterpart of the other, is more nearly round and its walls preserve a more even height. The slope up from the floor in both basins is gentle at first at the foot of the walls and then becomes steep. The walls are formed of roughly bedded lava flows interstratified and intermingled with mixtures of vesicular lava, scoria, pumice and volcanic sand. The harder lava layers project with vertical rocky faces, while between them softer zones have weathered away into débris slopes and produced a rough terraced effect, somewhat similar to that in the sides of the Grand Canyon of the Colorado. The height of the

walls above the level of the plain is on the average about 1,500 feet. It decreases toward the western side owing to the gradual rise of the floor in that direction, but increases at some points, as on the southwest and west sides, where mountains break the continuity of the horizon line.

From the brink of the wall around the whole circumference of the big crater, a wide plateau slopes gently away at an angle of only some five to eight degrees. One is apt to think of a crater as a pit on the apex of a sharp conical mountain. The crater of Aso has a cone, but its slopes are so moderate that one realizes only from a point of comprehensive outlook that this vast open bowl lies on the summit of a huge mound, which forms an upland of low relief in the center of Kiushiu.

The outward-sloping surface of this mound, as seen from above, is like a plateau, but it is without a single level place. No surface could be more wrinkled and still preserve the appearance of an inclined plane. It is completely made up of knolls and ridges and knobs, which continue off for many miles to the base of high encircling mountains. From the summit of Neko-dake these distant mountains are seen to surround this upland, much as the walls of the big crater surround its floor. The hillocks of the upland are overgrown in the early spring with long dry grass, but the cultivated bottoms between shine like emeralds, the green of the wheat being deepened here and there by the background of black soil upon which it grows.

From the peaks of the Aso range that divide the two well-populated plains long flowing ridges with concave slopes reach down into the floor. Between them are steep gorges. These ridges are not dwelt upon nor cultivated, probably on account of the lack of water, but like the hills of the outer plateau are grown over with rank grass. They contrast strongly with the richly tinted sweep of the crater bottoms. Considerable patches of the northern plain are sometimes flooded, and there is a legend that the big bowl of Aso was once occupied by a lake until a god kicked the hole in the wall to let the water out and leave the ground for cultivation. One can not but admire the conception of the ease and despatch with which this early piece of reclamation work was carried out.

Nearly all that has been described, and more, can be seen from the top of Neko-dake; so much, in fact, that two or three hours spent on the summit was all too short a time. The descent was quick down the steep slope, but the evening homeward jaunt to Takamori was one of many miles. The way led along a muddy black path; at first among bare fields, where peasant women had been at work all day gathering up corn stalks, loading them on oxen, and sending them home to be chopped up to feed the animals; and then among the endless paddy-fields of wheat and mustard. Finally 'home,' when reached, consisted

FIG. 5. THE MODERN MUD-CONE OF ASO-SAN WITH VAPORS ISSUING FROM THE NEW CRATER. In the foreground is a temple to the God Aso.

of a floor, a few bowls of rice, and a bath through which a dozen men had been before.

On another day the three of us set out for the modern crater. A walk of a few miles brought us to the village of Yoshida about opposite the central portion of the Aso range, whence a feasible way seemed to offer up to the low place in the range already noted. It led first over the end of a number of low ridges that radiate into the plain from the central mountains and then up an easy grassy slope to the top. Here we had expected a divide that would enable us to look over into the northern basin, but instead we found an expanse of almost level mound-strewn country mostly enclosed by the higher portions of the summit

and so wide that it intercepted all view. The mounds covering this upland were seemingly formed of soft volcanic débris and presented a straggling appearance. This summit country sloped upward on the east within less than a mile into a low cone some few hundred feet high, from which the steam clouds poured forth. Behind it on the southeast rose the forbidding-looking crags of Nakadake and on the east the flanks of Taka-dake to a much greater altitude.

At the foot of the cone on the desert-looking slope stood several huts and two small temples, one Buddhist and the other Shinto, built in honor of the god of Aso for the use of those who climb the mountain to worship. It is one of the beautiful features of the Japanese religion as practised by a great many of the people that it draws them out of doors and brings them in touch with nature. Almost every mountain is held in reverence, and many days during the course of the year are spent by the devout in excursions in the country or up into the mountains to pray on the high places.

It is a gentle ascent of only 200 or 300 feet from the rest house and the temples to the summit of the cone, first over a lava stream that looks as if it might have flowed but a little while before, then over a talus of lava, pumice and cinders, and finally over slippery, grey volcanic mud. At the top is the crater, a black, ragged, awful pit, roaring and steaming constantly. As one stands on the brink one looks down walls of roughly-stratified mud to a depth of 300 or 400 feet, where two round vents are continually rolling out masses of steam

FIG 6. LOOKING DOWN INTO THE MODERN CRATER OF ASO-SAN, showing the rough layers of mud in the walls and the bottom of one of the vents. Photo by Malcolm Anderson.

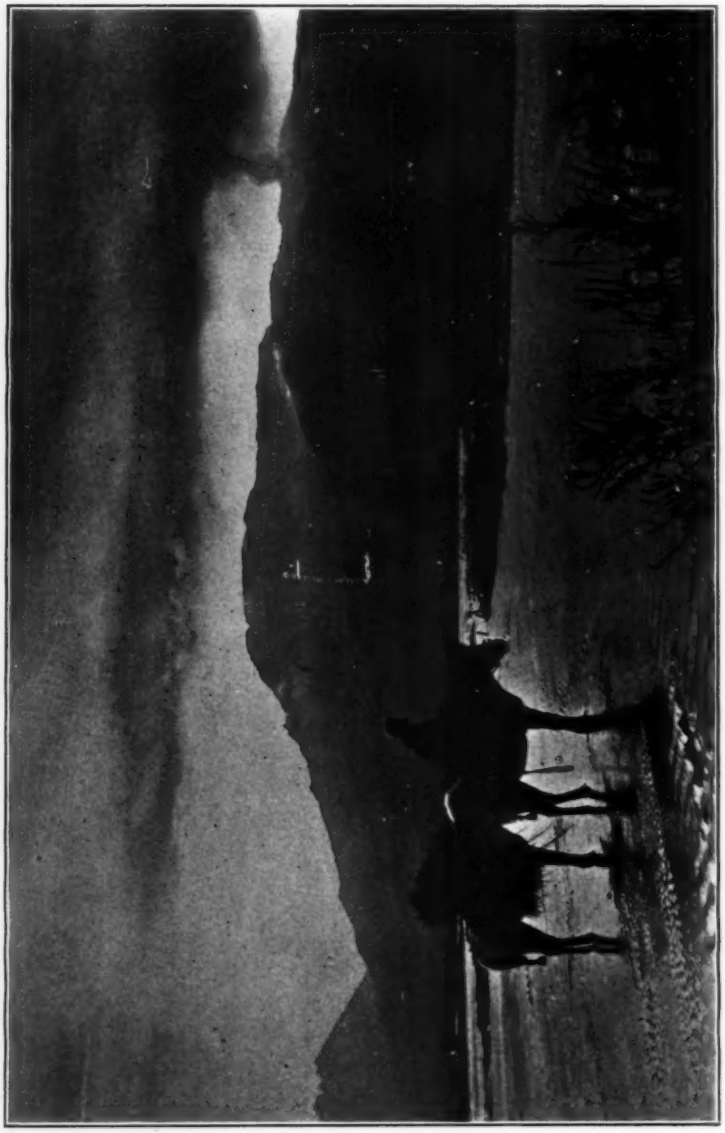

FIG. 7. LOOKING SOUTHEAST FROM THE STREAM ON THE FLOOR OF THE NORTHERN HALF OF THE OLD ASO CRATER OFF TO THE DIVIDING RANGE. A great vapor cloud rises from the new crater on the summit. In the center is Taka-dake, 4000 feet above the foreground, and on the left is part of Neko-dake.

and sulphur vapor and reverberating with explosive roars. This little crater has an oblong shape and is at a rough estimate 900 feet across and 2,000 feet long. Its rim is very uneven, being much higher on the north and east than on the other sides. It is divided into five compartments or vents, each separated from the other by a wall of mud, 100 feet or more high. The two already mentioned are the deepest and the only active ones, and occasionally, when the vapor column diminishes, one can look to the bottom of the northern vent and see the burning sulphur that plasters the lower walls and floor. The bottom is a round flat disc of cracked mud looking like the dried bottom of a pond, and there is no appearance of a hole or conduit descending to greater depths. The other of the two active crater holes is deeper and pours forth more steam. Its bottom can not be seen from any point upon the rim. The yellow sulphur fumes fill the air and become almost unbearable at times when the wind shifts the cloud a little towards one. We were able to follow the edge the whole way round the crater, a distance of about one and one half miles, but the going was difficult on account of the extremely slippery mud that forms the outer sides, which slope sharply away from the precipice on the interior. This soft, fine mud, both outside and inside the crater, is furrowed by rain and given a curious appearance. The other three vents, besides the two already mentioned, lie to the south along the axis of the crater. They are steep-walled, but not so deep as the other ones. They have flat bottoms of cracked mud, though in one the floor at the time of our visit was occupied by a shallow pool of water.

The view from points near the edge of the crater embraces a large part of the northern basin through a gap in the encircling heights on the north. But on all the other sides the rolling summit region is pretty well enclosed and looks a little as if it might have been at one time ages ago the site of a crateral basin much larger than the present active one.

At length the late hour and our extreme thirst after a warm day without water on these dry mountains drove us down from the heights. At the rest house by the temples we obtained a reviving drink of cold spring water, and on the bench where we sat to drink it we left all the change in our possession, which was a total of ten coins, amounting to nine tenths of a cent.

During the memory of man the crater on top of the Aso range has been active, and successive severe eruptions have again and again blown out ashes, cinders and bombs that have darkened the sky for many miles around and covered up the fields, have sent streams of mud mingled with hot water flooding down the mountain sides and over the plain, and caused terrifying noises and shakings of the ground. At such times crops and trees have been blighted and killed by the falling ash or by the heat and vapors, and the streams have been so

filled with débris and poisoned with bitter sulphurous water that the fish have died. Some say that the Shirakawa, which means 'white river,' owes its name to the milky color that it has been known to assume at such times. Loss of life has been occasioned by these outbursts, but the records do not make it clear to what extent. Reference is made in records to fiery rocks sometimes of great size that have been blown out, but lava flows do not seem to have assumed importance. Explosive eruptions of fine débris, as shown by the mud cone, have been predominant during the later history of the volcano.

FIG. 8. RECENT-LOOKING LAVA WITH SMOOTH FLOW STRUCTURE THAT HAS FLOWED DOWN A GULLY HIGH UP ON THE SOUTH SIDE OF NAKA-DAKE. In the distance, far across the great crater of Aso, may be faintly seen the horizon line of the outer wall. The whole foreground is covered with barren volcanic rock.

The greatest eruptions of very recent times were in the winter of 1873 to 1874, when unusual activity continued during several months and ashes covered the ground to a distance of 18 miles; in the winter of 1884, when ashes were blown over Kumamoto, making it so dark there at a distance of 25 miles that lamps had to be used for three days; in 1889, during the year of the Kumamoto earthquake, which was the year following the great explosions of Bandai-san in central Japan; and lastly in 1894, when the floor of the modern crater was somewhat altered.

The problem of old Mount Aso is a deep one. One can not view its gigantic outlines without wondering what forces could have molded them, what could have been the steps in the process of formation of this huge pit, its level floor, its steep walls, the gentle slopes radiating

from its outer rim, and of the rugged mountain bulwark in its center, on the summit of which the life of the volcano has been preserved in a far smaller inner crater. It seems inconceivable that processes alone of building-up could have resulted in such forms as those of Aso; and in attempting to outline its history one always reverts to some theory of destructive action on a very large scale.

The large crater of Aso may have been formed in either one of two ways, by the blowing off and away in some cataclysmic explosion, or series of explosions, the whole mass that must once have filled and overlain the present cavity, or by the sinking in of this same mass and its engulfment in a great void produced by the removal of the material that formerly gave support to the earth's surface at this point. A calculation, such as given below, of the mass displaced in either case affords an impressive sense of the magnitude of the task that was accomplished. The roughly-bedded strata in the walls of the big crater seem to dip away on all sides at a low angle, and their slope is probably reflected in the gently inclined surface of the outer plateau that forms the sides of the Aso cone. From the regularity of these slopes it seems likely that they represent the truncated base of an old conical mountain that continued upward with the present slope to a culminating point high above the center of what is now the crater bowl. It is probable that if such a mountain existed its upper portion rose with a gradually increasing slope into a peak, but even with a constant slope such as now exhibited in the base, its height would have been 7,000 to 7,500 feet above the sea, or about 6,000 feet higher than the present crater floor.

It is probable that during the early history of the volcano such a cone was built up by successive eruptions of lava and fragmental material that formed sheets one upon another down the sides and became roughly stratified in conformity with the slope of the mountain; and that before the close of the period of greatest activity of the volcano this cone was beheaded by some disruptive force. Not only was the summit removed, but the very heart of the volcano was opened, leaving a vast bowl on the site of the old eminence surrounded by the truncated lava flows of the outer circle of the mountain's base. Still later, the processes of building up recommencing, a new mountain was constructed, this time not over a single center as seems to have been the case before, but along the line of the short diameter of the former oval mountain, and in this way the present chain of peaks was raised. But the volcano was gradually dying down, and reconstruction on a grand scale ceased long before the new Aso had reached the dimensions of the old, or even effectually obscured, except to casual observation, the nature of its basal wreck.

The volume of the bowl of Aso, not subtracting the space that is taken up by the supposedly subsequent range, is at least nine cubic

FIG. 9. ONE OF THE MOST ACTIVE VOLCANOES OF JAPAN, KIRISHIMA-YAMA IN SOUTHERN From its summit, which is 6,000 feet high, may be seen Aso-san 70 miles away to the north.

miles. The mass that must once have overlain it, measured as the cone formed by the upward projection of the outer slopes, was at least 28 cubic miles in volume. Thus there must have been removed no less than 37 cubic miles, or about five and a half millions of millions of cubic feet of volcanic rock, a mass equal to over two and a half mountains like Vesuvius.

Furthermore the likelihood that the cone steepened toward its summit makes it possible that the old mountain was of greater size than estimated.

If we conceive of such a vast block of the earth's surface being blown up by some terrific explosion within the volcano, it is natural to suppose that great irregular deposits of the erupted material would be in evidence round the outside of the pit. There are immense areas of volcanic débris that have settled after being blown into the air, whole hills in places, within a radius of many miles of Aso. But these deposits seem to be regularly bedded and not to exhibit the rough and tumble structure that would probably result from their being tumultuously cast up by such a great explosion, and they do not form a rim around the crater rising above the old slopes of the cone. And further the walls of the pit seem to be too regular to have been explosively broken.

More acceptable appears the theory that the Aso crater is a sunken pit. A volcano of such magnitude must certainly have been underlain at some unknown depth by a large body of molten rock, the source of the lava that built up the cone. With all the weight exerted upon it by the overlying rocks and the pressure of steam from within, this fluid or viscous, intensely-heated mass must have sought violently for

KIUSHIU, AS SEEN FROM A DISTANCE. It has been in violent eruption during the last decade.

escape. Having, probably, found one or more points of discharge far below the summit of the cone, it flowed out in such vast quantities that it left a cavity large enough to engulf the whole of the unsupported mountain mass. The sinking was doubtless aided, and lessened in violence, by the partial fusion of the overlying rocks as they became more and more depressed, and probably the action took place around a common center. When the mountain summit had completely disappeared, there was left around about a regular curve of unbroken walls bearing witness to the comparative gentleness with which the action had been carried out. It is possible to consider the central Aso range as part of the old mountain that did not sink or become totally engulfed, but it seems more likely that it is a later growth. The completed work probably left the whole of the sunken mountain melted in a level lake within the great caldron. The radiating lava flows described in a later paragraph may help to account for the material removed.

After nearly two weeks spent in and about Aso we left it, setting out eastward to continue our march across Kiushiu to the Pacific, on the opposite side of the island from our starting point. The less precipitous portions of the crater wall are well-watered and clothed with beautiful groves of pines and cryptomerias, bamboos, oaks and chestnut trees, among which one finds little meadows and mossy places and banks overgrown with rich grass, where thrive an abundance of wild violets of various colors and sweet-smelling daphnes. Through these woods our road wound up out of the pit at a comparatively low and gently-rising portion of the wall, and finally over the crest of the rim to the far-sloping outer reaches. Within a few days more we

looked back at Aso from the top of Sobo-san, the highest mountain in the island, and appreciated more than ever the roundness of the crater and its great size, which can be better grasped from such a distance than from nearer at hand. The square, high block of Taka-dake and the turreted peak of Neko-dake stood impressively out of the huge bowl.

Some miles to the south and east of Aso-san the surface covering of volcanic ejectamenta which has filled up and blotted out the ancient features of the landscape ceases to be a solid sheet, but lava streams continue for great distances beyond, partly burying the old river channels that radiate away from the region occupied by Aso-san. Aso has evidently been the center of all the volcanic activity of this portion of Kiushiu, and the source of supply of the erupted material mantling the region. The longest of the lava arms follows the Gokase river for a distance of over 30 miles beyond the edge of the volcanic sheet as far as the sea, or a total distance of 50 miles from the volcano. It must have started as a broad stream or as successive streams of lava from Aso and have become narrowed into the old canyon of this river. The width of the present lava filling of the canyon is on the average 2½ to 3 miles, and the depth amounts certainly to several hundred feet.

The Gokase-gawa runs to the east coast, and down its canyon we took our course after a few more days in the heart of Kiushiu. The

FIG. 10. OVERLOOKING FROM THE HILLS THE BEAUTIFUL CITY AND BAY OF KAGOSHIMA IN SOUTHERNMOST JAPAN. In the deep bay stands the island volcano Sakura-jima, almost 4,000 feet high, another of the active volcanoes of Kiushiu. In 1863 this city was bombarded and partly burnt by an English admiral and his squadron. Again in 1877 it was set on fire during the last days of the Satsuma rebellion, and here at that time the final desperate stand of some of the Japanese nobility was made against the principle of Europeanization.

scenery was magnificent. High mountains rose on every hand out of the fairly wide and level bottom-land within the canyon. But this was not the old canyon bottom, it was the upper surface of the lava filling. We made this discovery on reaching the middle of the valley, where much to our surprise we came upon a tremendous gorge cut squarely out of it by the river, which is eating its way down again to find its old course. It has already reached a depth of 300 or 400 feet through the lava flow and has left a rift vertically walled on either side by columns of andesite that give a stately beauty to the cliffs. The river rushes down a steep channel, always growing with the addition of little tributaries, which tumble in over the parapet from out of jungles of greenery that overhang the edge and festoon the rocks with drooping purple tassels of wistaria. In its lower course it flows more quietly and widens, the rapids become less frequent and the canyon loses the intensity of its angles. But still the old lava flow continues. From the village of Takeshita, which means "below the falls," we took a rowboat and glided down the broad stream the rest of the way to the sea, away from the wild grandeur of the mountain scenery into the midst of the picturesque landscapes of the Japanese lowland.

# CONTROL OF THE COLORADO RIVER REGAINED

By CHARLES ALMA BYERS
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THE Colorado River, creator of the much-discussed Salton Sea, has at last been captured. Its waters, always of uncertain quantity and consequently often threatening, no longer are poured into Salton Sink by way of a river-like irrigation ditch, but instead flow peaceably into the Gulf of California as in the days before man had tampered with it for irrigation purposes. And incidental to the river's capture, Imperial Valley, that new agricultural region rescued by irrigation from the Colorado Desert, an area lying below the level of the sea, and a region that is some day destined to become worth millions of dollars, is no longer in danger of being inundated by the murky waters of this treacherous "yellow dragon" and consequently wiped practically out of existence.

The going astray of the Colorado River, and the trouble incidental thereto, which was described in THE POPULAR SCIENCE MONTHLY some months ago, has occasioned much study and deep concern by engineers all over the country, and has attracted the attention of the heads of two governments—the United States and Mexico. It has created an inland sea in Salton Sink, adjacent to Imperial Valley, that covers about 400 square miles, destroyed the works of the New Liverpool Salt Company, caused three different removals of several miles of the Southern Pacific Railroad, and necessitated the expenditure of many thousands of dollars towards its control, besides threatening to submerge the Imperial Valley, several small cities of considerable importance and a number of rich mineral deposits.

The trouble with the Colorado River, it will be recalled, began in September, 1904. The California Development Company, promoters of the Imperial land colony, needed more water for agricultural purposes than their old irrigation ditch was then supplying, and to remedy the shortage an incision was made in the banks of the river at a point about four miles below the old tapping point, and below the international boundary line between the United States and Mexico. A flood in the river soon cut this new channel so deep as to place the flow beyond control. Gradually this ditch was eroded into a river that at times carried the entire flow of the Colorado River, sometimes amounting to 40,000 second feet of water, and poured it into Salton Sink.

In all, six attempts had been made to capture the runaway river before the last and successful one. The first five, however, were poorly carried out and practically amounted to *nil* in the final success. The sixth proved better, and for a time it seemed to solve the problem. It was completed on November 4, 1906, and on the night of December 7, 1906, during the flood, the river again ate its way through the barrier of willow matting, piles, rocks and dirt and once more wended its way toward Salton Sink. This dam, called the Hind Dam, in honor of the field engineer, Thomas J. Hind, therefore withstood the rebellious-inclined Colorado for a period of only thirty-three days.

The Hind Dam, which, though not a success of itself, aided in the final capture, was a conglomerate creation 170 feet wide at the base, 30 feet across at the top and 35 feet high at the deepest places in the break. It was 3,000 feet in length, of which 600 feet was of rock construction and 2,400 feet of earth and gravel. Its foundation consisted of a heavy, strong mat of willow and cable, held in place by strong piles, about 1,100 in number and from forty to sixty feet in length. The mat was created by the use of 2,200 cords of willow, cut by Indians, 40 miles of five-eighths-inch woven steel cable, and 10,000 cable clips. It was 100 feet wide and 800 feet in length, divided into eighteen sections, and was laid across the river by being uncoiled from a barge floated across the stream.

The piles driven into the mat were also made to serve as a support for a temporary railroad. From this road carload after carload of material was dumped into the gap, in all there being 70,000 tons of rock, 40,000 cubic feet of gravel, 40,000 cubic feet of clay, and 100,000 sacks of sand, besides about 500,000 yards of dirt thrown up by teams and dredges. To carry on this work as many as 1,100 men and 600 horses and mules, besides several steam dredges, shovels, pile drivers and an almost endless string of freight cars, were employed at one time. The cost of the work to the Southern Pacific Railway Company, which, headed by Engineer Epes Randolph, engineered the undertaking, reached an average rate of $10,000 per day for one hundred days.

The break that occurred in the river after this dam was completed, in December, was at a part about 2,500 feet below the works, and was 1,100 feet wide. Colonel Randolph again assembled his forces, placed E. K. Clark, engineer of the Tucson division of the Southern Pacific Railroad, in direct charge, and work was recommenced to solve this troublesome problem. Another dam, called the Clarke Dam, was built and by it the Colorado River has at last been permanently confined to its old channel.

To build this dam no attempt to follow science was made. The Southern Pacific placed their entire road subject to the orders of the

engineers, and materials of almost every kind were rushed to the break from points far and near as fast as it could be taken care of. Piles were driven, a temporary road was constructed across the break, and there was almost a continual dumping of rock, gravel and dirt into the gap. A carload of material was dumped every seven minutes both day and night, and in the short period of thirteen days 100,000 tons were disposed of, bringing the dam up to water level. Much of this material was hauled a distance of 380 miles.

The Clarke Dam was practically completed February 10, 1906, and the river was declared conquered. The dam proper is 1,200 feet in length, of which 700 feet is of rock and 500 feet of gravel and earth. Work, however, did not cease with the completion of the dam, and, since February 10, several miles of earth embankment have been built to insure permanent success. This work will continue until about sixteen miles of levee is built along the west bank of the river, in addition to the two dams with a combined length of 4,200 feet. The river, in the vicinity of the breaks, or dams, and near the international boundary line, for a distance of about seven miles, flows through a throat only 2,160 feet wide, and is considerably higher than the territory lying to the west. The levee follows the river for this distance, and then swings away to the west towards the Black Buttes, leaving the river below this point to follow its own inclinations.

The California Development Company and the Southern Pacific Railroad Company have expended to date upon this work a sum in excess of $3,500,000. This is an enormous sum to dump into a river, it seems, but since the river is captured and all interests immune from further trouble, the two companies feel amply rewarded.

The United States government has inaugurated steps to place Imperial Valley in charge of the Government Reclamation Service, but what the outcome of the move will be is not yet known. In the meantime the California Development Company will conutine to manage the colony, and will install new head-gates for their irrigation ditches and otherwise improve the system. The farmers of the valley feel secure now for the first time in two years, and Imperial Valley promises to become a prospering community.

# THE VALUE OF SCIENCE

## SCIENCE AND REALITY

BY M. H. POINCARE

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### 5. *Contingence and Determinism*

I DO not intend to treat here the question of the contingence of the laws of nature, which is evidently insoluble, and on which so much has already been written. I only wish to call attention to what different meanings have been given to this word, contingence, and how advantageous it would be to distinguish them.

If we look at any particular law, we may be certain in advance that it can only be approximative. It is, in fact, deduced from experimental verifications, and these verifications were and could be only approximate. We should always expect that more precise measurements will oblige us to add new terms to our formulas; this is what has happened, for instance, in the case of Marriotte's law.

Moreover the statement of any law is necessarily incomplete. This enunciation should comprise the enumeration of *all* the antecedents in virtue of which a given consequent can happen. I should first describe *all* the conditions of the experiment to be made and the law would then be stated: If all the conditions are fulfilled, the phenomenon will happen.

But we shall be sure of not having forgotten *any* of these conditions only when we shall have described the state of the entire universe at the instant $t$; all the parts of this universe may, in fact, exercise an influence more or less great on the phenomenon which must happen at the instant $t + dt$.

Now it is clear that such a description could not be found in the enunciation of the law; besides, if it were made, the law would become incapable of application; if one required so many conditions, there would be very little chance of their ever being all realized at any moment.

Then as one can never be certain of not having forgotten some essential condition, it can not be said: If such and such conditions are realized, such a phenomenon will occur; it can only be said: If such and such conditions are realized, it is probable that such a phenomenon will occur, very nearly.

Take the law of gravitation, which is the least imperfect of all known laws. It enables us to foresee the motions of the planets. When I use it, for instance, to calculate the orbit of Saturn, I neglect the action of the stars, and in doing so, I am certain of not deceiving myself, because I know that these stars are too far away for their action to be sensible.

I announce, then, with a quasi-certitude that the coordinates of Saturn at such an hour will be comprised between such and such limits. Yet is that certitude absolute? Could there not exist in the universe some gigantic mass, much greater than that of all the known stars and whose action could make itself felt at great distances? That mass might be animated by a colossal velocity, and after having circulated from all time at such distances that its influence had remained hitherto insensible to us, it might come all at once to pass near us. Surely it would produce in our solar system enormous perturbations that we could not have foreseen. All that can be said is that such an event is wholly improbable, and then, instead of saying: Saturn will be near such a point of the heavens, we must limit ourselves to saying: Saturn will probably be near such a point of the heavens. Although this probability may be practically equivalent to certainty, it is only a probability.

For all these reasons, no particular law will ever be more than approximate and probable. Scientists have never failed to recognize this truth; only they believe, right or wrong, that every law may be replaced by another closer and more probable, that this new law will itself be only provisional, but that the same movement can continue indefinitely, so that science in progressing will possess laws more and more probable, that the approximation will end by differing as little as you choose from exactitude and the probability from certitude.

If the scientists who think thus were right, must it still be said that *the* laws of nature are contingent, even though *each* law, taken in particular, may be qualified as contingent? Or must one require, before concluding the contingence *of the* natural laws, that this progress have an end, that the scientist finish some day by being arrested in his search for a closer and closer approximation and that, beyond a certain limit, he thereafter meet in nature only caprice?

In the conception of which I have just spoken (and which I shall call the scientific conception), every law is only a statement, imperfect and provisional, but it must one day be replaced by another, a superior law, of which it is only a crude image. No place therefore remains for the intervention of a free will.

It seems to me that the kinetic theory of gases will furnish us a striking example.

You know that in this theory all the properties of gases are ex-

plained by a simple hypothesis; it is supposed that all the gaseous molecules move in every direction with great velocities and that they follow rectilineal paths which are disturbed only when one molecule passes very near the sides of the vessel or another molecule. The effects our crude senses enable us to observe are the mean effects, and in these means, the great deviations compensate, or at least it is very improbable that they do not compensate; so that the observable phenomena follow simple laws such as that of Mariotte or of Gay-Lussac. But this compensation of deviations is only probable. The molecules incessantly change place and in these continual displacements the figures they form pass successively through all possible combinations. Singly these combinations are very numerous; almost all are in conformity with Mariotte's law, only a few deviate from it. These also will happen, only it would be necessary to wait a long time for them. If a gas were observed during a sufficiently long time, it would certainly be finally seen to deviate, for a very short time, from Mariotte's law. How long would it be necessary to wait? If it were desired to calculate the probable number of years, it would be found that this number is so great that to write only the number of places of figures employed would still require half a score places of figures. No matter; enough that it may be done.

I do not care to discuss here the value of this theory. It is evident that if it be adopted, Mariotte's law will thereafter appear only as contingent, since a day will come when it will not be true. And yet, think you the partisans of the kinetic theory are adversaries of determinism? Far from it; they are the most ultra of mechanists. Their molecules follow rigid paths, from which they depart only under the influence of forces which vary with the distance, following a perfectly determinate law. There remains in their system not the smallest place either for freedom, or for an evolutionary factor, properly so-called, or for anything whatever that could be called contingence. I add, to avoid mistake, that neither is there any evolution of Mariotte's law itself; it ceases to be true after I know not how many centuries; but at the end of a fraction of a second it again becomes true and that for an incalculable number of centuries.

And since I have pronounced the word evolution, let us clear away another mistake. It is often said: Who knows whether the laws do not evolve and whether we shall not one day discover that they were not at the Carboniferous epoch what they are to-day? What are we to understand by that? What we think we know about the past state of our globe, we deduce from its present state. And how is this deduction made? It is by means of laws supposed known. The law being a relation between the antecedent and the consequent, enables us equally well to deduce the consequent from the antecedent, that is, to

foresee the future, and to deduce the antecedent from the consequent, that is, to conclude from the present to the past. The astronomer who knows the present situation of the stars can from it deduce their future situation by Newton's law, and this is what he does when he constructs ephemerides; and he can equally deduce from it their past situation. The calculations he thus can make can not teach him that Newton's law will cease to be true in the future, since this law is precisely his point of departure; not more can they tell him it was not true in the past. Still in what concerns the future, his ephemerides can one day be tested and our descendants will perhaps recognize that they were false. But in what concerns the past, the geologic past which had no witnesses, the results of his calculation, like those of all speculations where we seek to deduce the past from the present, escape by their very nature every species of test. So that if the laws of nature were not the same in the Carboniferous age as at the present epoch, we shall never be able to know it, since we can know nothing of this age only what we deduce from the hypothesis of the permanence of these laws.

Perhaps it will be said that this hypothesis might lead to contradictory results and that we shall be obliged to abandon it. Thus, in what concerns the origin of life, we may conclude that there have always been living beings, since the present world shows us always life springing from life; and we may also conclude that there have not always been, since the application of the existent laws of physics to the present state of our globe teaches us that there was a time when this globe was so warm that life on it was impossible. But contradictions of this sort can always be removed in two ways; it may be supposed that the actual laws of nature are not exactly what we have assumed; or else it may be supposed that the laws of nature actually are what we have assumed, but that it has not always been so.

It is evident that the actual laws will never be sufficiently well known for us not to be able to adopt the first of these two solutions and for us to be constrained to infer the evolution of natural laws.

On the other hand, suppose such an evolution; assume, if you wish, that humanity lasts sufficiently long for this evolution to have witnesses. The *same* antecedent shall produce, for instance, different consequents at the Carboniferous epoch and at the Quaternary. That evidently means that the antecedents are closely alike; if all the circumstances were identical, the Carboniferous epoch would be indistinguishable from the Quaternary. Evidently this is not what is supposed. What remains is that such antecedent, accompanied by such accessory circumstance, produces such consequent; and that the same antecedent, accompanied by such other accessory circumstance, produces such other consequent. Time does not enter into the affair.

The law, such as ill-informed science would have stated it, and which would have affirmed that this antecedent always produces this consequent, without taking account of the accessory circumstances, this law, which was only approximate and probable, must be replaced by another law more approximate and more probable, which brings in these accessory circumstances. We always come back, therefore, to that same process which we have analyzed above, and if humanity should discover something of this sort, it would not say that it is the laws which have evoluted, but the circumstances which have changed.

Here, therefore, are several different senses of the word contingence. M. LeRoy retains them all and he does not sufficiently distinguish them, but he introduces a new one. Experimental laws are only approximate, and if some appear to us as exact, it is because we have artificially transformed them into what I have above called a principle. We have made this transformation freely, and as the caprice which has determined us to make it is something eminently contingent, we have communicated this contingence to the law itself. It is in this sense that we have the right to say that determinism supposes freedom, since it is freely that we become determinists. Perhaps it will be found that this is to give large scope to nominalism and that the introduction of this new sense of the word contingence will not help much to solve all those questions which naturally arise and of which we have just been speaking.

I do not at all wish to investigate here the foundations of the principle of induction; I know very well that I shall not succeed; it is as difficult to justify this principle as to get on without it. I only wish to show how scientists apply it and are forced to apply it.

When the same antecedent recurs, the same consequent must likewise recur; such is the ordinary statement. But reduced to these terms this principle could be of no use. For one to be able to say that the same antecedent recurred, it would be necessary for the circumstances *all* to be reproduced, since no one is absolutely indifferent, and for them to be *exactly* reproduced. And, as that will never happen, the principle can have no application.

We should therefore modify the enunciation and say: If an antecedent $A$ has once produced a consequent $B$, an antecedent $A'$, slightly different from $A$, will produce a consequent $B'$, slightly different from $B$. But how shall we recognize that the antecedents $A$ and $A'$ are "slightly different"? If some one of the circumstances can be expressed by a number, and this number has in the two cases values very near together, the sense of the phrase "slightly different" is relatively clear; the principle then signifies that the consequent is a continuous function of the antecedent. And as a practical rule, we reach this conclusion that we have the right to interpolate. This

is in fact what scientists do every day, and without interpolation all science would be impossible.

Yet observe one thing. The law sought may be represented by a curve. Experiment has taught us certain points of this curve. In virtue of the principle we have just stated, we believe these points may be connected by a continuous graph. We trace this graph with the eye. New experiments will furnish us new points of the curve. If these points are outside of the graph traced in advance, we shall have to modify our curve, but not to abandon our principle. Through any points, however numerous they may be, a continuous curve may always be passed. Doubtless, if this curve is too capricious, we shall be shocked (and we shall even suspect errors of experiment), but the principle will not be directly put at fault.

Furthermore, among the circumstances of a phenomenon, there are some that we regard as negligible, and we shall consider $A$ and $A'$ as slightly different if they differ only by these accessory circumstances. For instance, I have ascertained that hydrogen unites with oxygen under the influence of the electric spark, and I am certain that these two gases will unite anew, although the longitude of Jupiter may have changed considerably in the interval. We assume, for instance, that the state of distant bodies can have no sensible influence on terrestrial phenomena, and that seems in fact requisite, but there are cases where the choice of these practically indifferent circumstances admits of more arbitrariness or, if you choose, requires more tact.

One more remark: The principle of induction would be inapplicable if there did not exist in nature a great quantity of bodies like one another, or almost alike, and if we could not infer, for instance, from one bit of phosphorus to another bit of phosphorus.

If we reflect on these considerations, the problem of determinism and of contingence will appear to us in a new light.

Suppose we were able to embrace the series of all phenomena of the universe in the whole sequence of time. We could envisage what might be called the *sequences,* I mean relations between antecedent and consequent. I do not wish to speak of constant relations or laws, I envisage separately (individually, so to speak) the different sequences realized.

We should then recognize that among these sequences there are no two altogether alike. But, if the principle of induction, as we have just stated it, is true, there will be those almost alike and that can be classed alongside one another. In other words, it is possible to make a classification of sequences.

It is to the possibility and the legitimacy of such a classification that determinism, in the end, reduces. This is all that the preceding analysis leaves of it. Perhaps under this modest form it will seem less appalling to the moralist.

It will doubtless be said that this is to come back by a detour to M. LeRoy's conclusion which a moment ago we seemed to reject: we are determinists voluntarily. And in fact all classification supposes the active intervention of the classifier. I agree that this may be maintained, but it seems to me that this detour will not have been useless and will have contributed to enlighten us a little.

### 6. *Objectivity of Science*

I arrive at the question set by the title of this article: What is the objective value of science? And first what should we understand by objectivity?

What guarantees the objectivity of the world in which we live is that this world is common to us with other thinking beings. Through the communications that we have with other men, we receive from them ready-made reasonings; we know that these reasonings do not come from us and at the same time we recognize in them the work of reasonable beings like ourselves. And as these reasonings appear to fit the world of our sensations, we think we may infer that these reasonable beings have seen the same thing as we; thus it is we know we have not been dreaming.

Such, therefore, is the first condition of objectivity; what is objective must be common to many minds and consequently transmissible from one to the other, and as this transmission can only come about by that "discourse" which inspires so much distrust in M. LeRoy, we are even forced to conclude: no discourse, no objectivity.

The sensations of others will be for us a world eternally closed. We have no means of verifying that the sensation I call red is the same as that which my neighbor calls red.

Suppose that a cherry and a red poppy produce on me the sensation $A$ and on him the sensation $B$ and that, on the contrary, a leaf produces on me the sensation $B$ and on him the sensation $A$. It is clear we shall never know anything about it; since I shall call red the sensation $A$ and green the sensation $B$, while he will call the first green and the second red. In compensation, what we shall be able to ascertain is that, for him as for me, the cherry and the red poppy produce the *same* sensation, since he gives the same name to the sensations he feels and I do the same.

Sensations are therefore intransmissible, or rather all that is pure quality in them is intransmissible and forever impenetrable. But it is not the same with relations between these sensations.

From this point of view, all that is objective is devoid of all quality and is only pure relation. Certes, I shall not go so far as to say that objectivity is only pure quantity (this would be to particularize too far the nature of the relations in question), but we understand

how some one could have been carried away into saying that the world is only a differential equation.

With due reserve regarding this paradoxical proposition, we must nevertheless admit that nothing is objective which is not transmissible, and consequently that the relations between the sensations can alone have an objective value.

Perhaps it will be said that the esthetic emotion, which is common to all mankind, is proof that the qualities of our sensations are also the same for all men and hence are objective. But if we think about this, we shall see that the proof is not complete; what is proved is that this emotion is aroused in John as in James by the sensations to which James and John give the same name or by the corresponding combinations of these sensations; either because this emotion is associated in John with the sensation *A*, which John calls red, while parallelly it is associated in James with the sensation *B*, which James calls red; or better because this emotion is aroused, not by the qualities themselves of the sensations, but by the harmonious combination of their relations of which we undergo the unconscious impression.

Such a sensation is beautiful, not because it possesses such a quality, but because it occupies such a place in the woof of our associations of ideas, so that it can not be excited without putting in motion the 'receiver' which is at the other end of the thread and which corresponds to the artistic emotion.

Whether we take the moral, the esthetic or the scientific point of view, it is always the same thing. Nothing is objective except what is identical for all; now we can only speak of such an identity if a comparison is possible, and can be translated into a 'money of exchange' capable of transmission from one mind to another. Nothing, therefore, will have objective value except what is transmissible by 'discourse,' that is, intelligible.

But this is only one side of the question. An absolutely disordered aggregate could not have objective value since it would be unintelligible, but no more can a well-ordered assemblage have it, if it does not correspond to sensations really experienced. It seems to me superfluous to recall this condition, and I should not have dreamed of it, if it had not lately been maintained that physics is not an experimental science. Although this opinion has no chance of being adopted either by physicists or by philosophers, it is well to be warned so as not to let oneself slip over the declivity which would lead thither. Two conditions are therefore to be fulfilled, and if the first separates reality[2] from the dream, the second distinguishes it from the romance.

[2] I here use the word real as a synonym of objective; I thus conform to common usage; perhaps I am wrong, our dreams are real, but they are not objective.

Now what is science? I have explained in the preceding article, it is before all a classification, a manner of bringing together facts which appearances separate, though they were bound together by some natural and hidden kinship. Science, in other words, is a system of relations. Now we have just said, it is in the relations alone that objectivity must be sought; it would be vain to seek it in beings considered as isolated from one another.

To say that science can not have objective value since it teaches us only relations, this is to reason backwards, since, precisely, it is relations alone which can be regarded as objective.

External objects, for instance, for which the word *object* was invented, are really *objects* and not fleeting and fugitive appearances, because they are not only groups of sensations, but groups cemented by a constant bond. It is this bond, and this bond alone, which is the object in itself, and this bond is a relation.

Therefore, when we ask what is the objective value of science, that does not mean: Does science teach us the true nature of things? but it means: Does it teach us the true relations of things?

To the first question, no one would hesitate to reply, no; but I think we may go farther; not only science can not teach us the nature of things; but nothing is capable of teaching it to us and if any god knew it, he could not find words to express it. Not only can we not divine the response, but if it were given to us, we could understand nothing of it; I ask myself even whether we really understand the question.

When, therefore, a scientific theory pretends to teach us what heat is, or what is electricity, or life, it is condemned beforehand; all it can give us is only a crude image. It is, therefore, provisional and crumbling.

The first question being out of reason, the second remains. Can science teach us the true relations of things? What it joins together should that be put asunder, what it puts asunder should that be joined together?

To understand the meaning of this new question, it is needful to refer to what was said above on the conditions of objectivity. Have these relations an objective value? That means: Are these relations the same for all? Will they still be the same for those who shall come after us?

It is clear that they are not the same for the scientist and the ignorant person. But that is unimportant, because if the ignorant person does not see them all at once, the scientist may succeed in making him see them by a series of experiments and reasonings. The thing essential is that there are points on which all those acquainted with the experiments made can reach accord.

The question is to know whether this accord will be durable and whether it will persist for our successors. It may be asked whether the unions that the science of to-day makes will be confirmed by the science of to-morrow. To affirm that it will be so we can not invoke any *a priori* reason; but this is a question of fact, and science has already lived long enough for us to be able to find out by asking its history whether the edifices it builds stand the test of time, or whether they are only ephemeral constructions.

Now what do we see? At the first blush it seems to us that the theories last only a day and that ruins upon ruins accumulate. To-day the theories are born, to-morrow they are the fashion, the day after to-morrow they are classic, the fourth day they are superannuated, and the fifth they are forgotten. But if we look more closely, we see that what thus succumb are the theories, properly so called, those which pretend to teach us what things are. But there is in them something which usually survives. If one of them has taught us a true relation, this relation is definitively acquired, and it will be found again under a new disguise in the other theories which will successively come to reign in place of the old.

Take only a single example: The theory of the undulations of the ether taught us that light is a motion; to-day fashion favors the electromagnetic theory which teaches us that light is a current. We do not consider whether we could reconcile them and say that light is a current, and that this current is a motion. As it is probable in any case that this motion would not be identical with that which the partisans of the old theory presume, we might think ourselves justified in saying that this old theory is dethroned. And yet something of it remains, since between the hypothetical currents which Maxwell supposes there are the same relations as between the hypothetical motions that Fresnel supposed. There is, therefore, something which remains over and this something is the essential. This it is which explains how we see the present physicists pass without any embarrassment from the language of Fresnel to that of Maxwell. Doubtless many connections that were believed well established have been abandoned, but the greatest number remain and it would seem must remain.

And for these, then, what is the measure of their objectivity? Well, it is precisely the same as for our belief in external objects. These latter are real in this, that the sensations they make us feel appear to us as united to each other by I know not what indestructible cement and not by the hazard of a day. In the same way science reveals to us between phenomena other bonds finer but not less solid; these are threads so slender that they long remained unperceived, but once noticed there remains no way of not seeing them; they are therefore not less real than those which give their reality to external objects; small

matter that they are more recently known since neither can perish before the other.

It may be said, for instance, that the ether is no less real than any external body; to say this body exists is to say there is between the color of this body, its taste, its smell, an intimate bond, solid and persistent; to say the ether exists is to say there is a natural kinship between all the optical phenomena, and neither of the two propositions has less value than the other.

And the scientific syntheses have in a sense even more reality than those of the ordinary senses, since they embrace more terms and tend to absorb in them the partial syntheses.

It will be said that science is only a classification and that a classification can not be true, but convenient. But it is true that it is convenient, it is true that it is so not only for me, but for all men; it is true that it will remain convenient for our descendants; it is true finally that this can not be by chance.

In sum, the sole objective reality consists in the relations of things whence results the universal harmony. Doubtless these relations, this harmony, could not be conceived outside of a mind which conceives them. But they are nevertheless objective because they are, will become, or will remain, common to all thinking beings.

This will permit us to revert to the question of the rotation of the earth which will give us at the same time a chance to make clear what precedes by an example.

### 7. *The Rotation of the Earth*

". . . Therefore," have I said in *Science and Hypothesis,* "this affirmation, the earth turns round, has no meaning . . . or rather these two propositions, the earth turns round, and, it is more convenient to suppose that the earth turns round, have one and the same meaning."

These words have given rise to the strangest interpretations. Some have thought they saw in them the rehabilitation of Ptolemy's system, and perhaps the justification of Galileo's condemnation.

Those who had read attentively the whole volume could not, however, delude themselves. This truth, the earth turns round, was put on the same footing as Euclid's postulate, for example. Was that to reject it? But better; in the same language it may very well be said: These two propositions, the external world exists, or, it is more convenient to suppose that it exists, have one and the same meaning. So the hypothesis of the rotation of the earth would have the same degree of certitude as the very existence of external objects.

But after what we have just explained in the fourth part, we may go farther. A physical theory, we have said, is by so much the more

true, as it puts in evidence more true relations. In the light of this new principle, let us examine the question which occupies us.

No, there is no absolute space; these two contradictory propositions: 'The earth turns round' and 'The earth does not turn round' are, therefore, neither of them more true than the other. To affirm one while denying the other, *in the kinematic sense,* would be to admit the existence of absolute space.

But if the one reveals true relations that the other hides from us, we can nevertheless regard it as physically more true than the other, since it has a richer content. Now in this regard no doubt is possible.

Behold the apparent diurnal motion of the stars, and the diurnal motion of the other heavenly bodies, and besides, the flattening of the earth, the rotation of Foucault's pendulum, the gyration of cyclones, the trade-winds, what not else? For the Ptolemaist all these phenomena have no bond between them; for the Copernican they are produced by the one same cause. In saying, the earth turns round, I affirm that all these phenomena have an intimate relation, and *that is true,* and that remains true, although there is not and can not be absolute space.

So much for the rotation of the earth upon itself; what shall we say of its revolution around the sun? Here again, we have three phenomena which for the Ptolemaist are absolutely independent and which for the Copernican are referred back to the same origin; they are the apparent displacements of the planets on the celestial sphere, the aberration of the fixed stars, the parallax of these same stars. Is it by chance that all the planets admit an inequality whose period is a year, and that this period is precisely equal to that of aberration, precisely equal besides to that of parallax? To adopt Ptolemy's system is to answer, yes; to adopt that of Copernicus is to answer, no; this is to affirm that there is a bond between the three phenomena and that also is true although there is no absolute space.

In Ptolemy's system, the motions of the heavenly bodies can not be explained by the action of central forces, celestial mechanics is impossible. The intimate relations that celestial mechanics reveals to us between all the celestial phenomena are true relations; to affirm the immobility of the earth would be to deny these relations, that would be to fool ourselves.

The truth for which Galileo suffered remains, therefore, the truth, although it has not altogether the same meaning as for the vulgar, and its true meaning is much more subtle, more profound and more rich.

### 8. *Science for Its Own Sake*

Not against M. LeRoy do I wish to defend science for its own sake; may be this is what he condemns, but this is what he cultivates, since

he loves and seeks truth and could not live without it. But I have some thoughts to express.

We can not know all facts and it is necessary to choose those which are worthy of being known. According to Tolstoi, scientists make this choice at random, instead of making it, which would be reasonable, with a view to practical applications. On the contrary, scientists think that certain facts are more interesting than others, because they complete an unfinished harmony, or because they make one foresee a great number of other facts. If they are wrong, if this hierarchy of facts that they implicitly postulate is only an idle illusion, there could be no science for its own sake, and consequently there could be no science. As for me, I believe they are right, and, for example, I have shown above what is the high value of astronomical facts, not because they are capable of practical applications, but because they are the most instructive of all.

It is only through science and art that civilization is of value. Some have wondered at the formula: science for its own sake; and yet it is as good as life for its own sake, if life is only misery; and even as happiness for its own sake, if we do not believe that all pleasures are of the same quality, if we do not wish to admit that the goal of civilization is to furnish alcohol to people who love to drink.

Every act should have an aim. We must suffer, we must work, we must pay for our place at the game, but this is for seeing's sake; or at the very least that others may one day see.

All that is not thought is pure nothingness; since we can think only thought and all the words we use to speak of things can express only thoughts, to say there is something other than thought, is therefore an affirmation which can have no meaning.

And yet—strange contradiction for those who believe in time—geologic history shows us that life is only a short episode between two eternities of death, and that, even in this episode, conscious thought has lasted and will last only a moment. Thought is only a gleam in the midst of a long night.

But it is this gleam which is everything.

# THE NEWER HYGIENE[1]

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INSTRUCTION in the nature of infectious diseases, especially in the means of transmitting these diseases from one person to another, is required by law in all our public schools. This law is of great value; for it is only through the intelligent cooperation of a well-informed public, that hygienic and sanitary measures designed to control and stamp out infectious diseases can be successful. A wide diffusion of this knowledge will go far to make tuberculosis a thing of the past, and diphtheria and small-pox unknown.

In obedience to the legal requirement, there are taught, in our public schools, certain elementary facts regarding the nature of pathogenic bacteria, and certain facts regarding the ways in which they are transmitted from one person to another. These facts in themselves are of inestimable value. But they are insufficient.

The presence of bacteria within or upon the human body, the transmission of disease-germs from the sick to the well, is but one of the factors tending to cause disease. To acquire a disease it is necessary, not only to acquire the germs of that disease, but there usually must be a lowering of bodily resistance as well.

Every fourth person in this room is carrying daily in his throat and mouth virulent pneumococci. Yet he does not acquire pneumonia. And why? Because there is an efficient defense against this disease in the healthy human body. Some day this defense will be lowered and pneumonia develop. Most soldiers in the Philippines carry in their intestinal canals virulent germs of dysentery; and with no ill effects, till intoxication or dietary excesses lower the intestinal resistance. We daily inhale germs of tuberculosis. Some day, when our resistance is low, we acquire the disease.

A knowledge of the body's fighting power against bacteria, a knowledge of the ways in which that power can be increased or decreased by hereditary influences and by modes of life, is therefore of hygienic importance, and should form part of the curriculum of every public school.

The body fights disease in many ways. It will be sufficient for hygienic purposes to teach but three of these ways: the method of antitoxines, the method of antiseptics and the method of phagocytosis.

[1] An address before the Indiana Academy of Science, at Indianapolis, December 1, 1906.

There are many diseases in which the symptoms are caused, not by the bacteria themselves, but by the chemical poisons the bacteria manufacture. Thus, in tetanus, or lock-jaw, the bacteria grow, perhaps unnoticed, at the bottom of the Fourth-of-July wound on the hand or foot; but the chemical poisons they manufacture, carried by the blood to the brain and spinal cord, cause the spasms and convulsions that characterize the disease. In diphtheria, the bacteria rarely enter the body, but grow in grayish-white masses on the moist surfaces of the mouth and throat. The chemical poisons they manufacture, absorbed by the tissues, cause the paralysis and heart failure that characterize the disease.

The body has the power of forming substances that neutralize these poisons. To these neutralizing substances the name antitoxine has been given.

This fact is of hygienic importance for two reasons. First, because it is sometimes possible to assist the body in its efforts to form antitoxines, by introducing into it antitoxines artificially prepared; and, second, because the body's power to form these substances is modified by mode of life. A horse that has been repeatedly injected with poison manufactured by the germs of diphtheria growing on an artificial culture medium, develops enormous amounts of diphtheria antitoxine. A few drops of its serum will render harmless large quantities of diphtheria poison.[1] Overwork, insufficient clothing, improper food, alcoholic excesses, lack of sleep, and other factors, so lower the antitoxine-forming power of the human body, as to greatly increase the dangers from infection.

The second way of hygienic importance in which the body fights disease is by the formation of chemical substances that, although they have no influence on the poisons manufactured by bacteria, have an even more important property, that of killing the bacteria themselves. The presence of these antiseptic, or bacteria-killing substances in the blood and tissue juices is easily shown. One has but to mix bacteria with serum, and test, from time to time, by simply cultural methods,[2] whether or not the bacteria are alive. Thus, in one experiment, there were mixed with human serum germs of typhoid fever in such numbers that every drop of the serum contained 50,000 bacteria. Two minutes later, but 20,000 of these were alive; at the end of ten minutes, but 800; and in twenty-five minutes, they were all dead.

Not only can serum kill bacteria, but most of the secretions of the healthy human body are bacteria-killing as well. Gastric juice, vaginal secretion and nasal secretion, kill bacteria in enormous numbers. The

[1] Through the use of diphtheria antitoxine in practical medicine the mortality from diphtheria has been reduced from the 24 per cent. to 40 per cent. it was, twenty years ago, to the less than 1 per cent. it now is, in well-treated cases.

[2] See POPULAR SCIENCE MONTHLY, Vol. 66, pp. 474–477.

hygienic significance of this is evident from the fact that these bacteria-killing substances, also, are modified by modes of life. Dietary excesses may so lower the bacteria-killing properties of gastric juice, and unsanitary conditions so lessen that of tissue juices, that susceptibility to infectious diseases is greatly increased.

The third way of hygienic importance in which the body fights disease is by phagocytosis. In the body there are millions of white blood corpuscles, each having the power of independent motion and as one of its functions the faculty of eating and destroying disease germs.

It is found that the bacteria-eating power of white corpuscles is largely dependent upon certain chemical substances[3] present in the blood and tissue juices. Without these substances, the eating of certain pathogenic bacteria does not take place. With them, it is very active. It is further found that these chemical substances are influenced by modes of life. That they may be increased or decreased under different hygienic conditions. Phagocytosis, therefore, has also a place in popular hygienic knowledge.

One of the unfortunate results of the spread of knowledge of pathogenic microorganisms is the formation of an unreasoning popular fear of disease germs. It is thought that a wide understanding of facts regarding bodily resistance will tend to replace this unfortunate germ-fear by a rational faith in the body's marvelous powers. That it may turn the tide of hygienic endeavor from an exclusive fight against bacteria to a combined fight *against* bacteria and *for* bodily resistance.

[3] Opsonins.

# THE FORMS OF SELECTION WITH REFERENCE TO THEIR APPLICATION TO MAN

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WHAT is the importance of natural selection in mankind is a question often asked. It is about as often answered without analysis. Put in this very general [illegible] it contains, and confuses, several different questions.

It is alleged that the conditions of life are so much improved by civilization that the struggle for existence is vanishing. Is that struggle, then, the only means of selection? And even if the cruder forms of selection are coming to be of little importance in man—which is doubtless the fact—are there not other kinds of selection still to be considered? It is time to analyze selection and determine its species. Then, when we know the kinds of selection, we may ask, with specific reference to each particular one: What is *its* importance in the present evolution of man? How far is each kind of selection operative in civilized society?

In our task of classification, let us consider first Darwin's division. By his choice of a name for natural selection, Darwin assigns to nature a work analogous to that of the breeder of domestic animals. Natural and artificial are therefore two kinds or species of selection. The latter species is more definitely named breeder's selection. Thus we obtain a first and provisional classification of the forms of selection as

## Natural Selection and Breeder's Selection

This simple classification is of importance, rather for an understanding of the meaning of the term natural selection, as Darwin thought of it, than for our particular purposes. But we need to dwell upon it somewhat, and dispose of it, before attempting a more adequate analysis.

The analogy from which the term natural selection is derived suggests a personification of nature. But natural selection is explicitly contrasted with conscious and personal factors.[1] Nature's action is

[1] Though requiring such a *caveat*, Darwin's use of the term "natural selection" is a just and appropriate development in the meaning of the words. A possible wrong first impression is corrected by the most elementary knowledge of the subject. Not as much can be said for the proposed alternative, "survival of the fittest." The "fittest" can not well be further defined than as the fittest *to survive*. Thus we get back to mere survival. What we need to add to this

impersonal and unconscious. It is not choice. Breeder's selection, on the other hand, is consciously directed towards a known and very definite end, the chosen "points." The action of natural selection is no more conscious than is the action of the current of water that separates pebbles from sand. This is the first great difference between natural selection and breeder's selection.

In another respect nature's agency in selection differs fundamentally from that of the breeder. The mode of operation of breeder's selection is positive; that of natural selection is negative. Natural selection eliminates by death the less well adapted members of a species. The better adapted survive and reproduce their kind. It does not matter in what respect they are better adapted. Protection from enemies is achieved in the case of the porcupine by his quills. The deer is saved by fleetness; wild cattle by the herding instinct, and by the effective use of horns and hoofs which that makes possible. No particular sort of quality is favored by natural selection, but those lacking in any respect are cut off. Nature has no plan. The line of evolution may take any direction; only, whatever the direction of improvement, woe to the hindmost. We have already seen that breeder's selection is conscious. That means its action is also positive. Attention is directed to reproducing and further evolving a favored type. The fan-tail pigeon exists because breeder's sought to develop a type with an unusually large number of tail feathers. The fleece of the better breeds of sheep has become fine and long because breeders sought this particular result. Breeder's selection positively favors certain individuals and types. Natural selection is primarily destructive of the inferior. It is negative. Incidentally it allows certain better adapted individuals to survive.

The third difference between natural selection and breeder's selection is that the latter operates directly on propagation, not necessarily by death. In "nature," this is among wild animals, the capacity to survive is the whole story. It may in general be assumed that a wild animal that survives to maturity, and lives through its prime, will reproduce its kind. Though it is the essential point always, propagation is not in general the crucial point with lower animals.[2] Among

is the notion of selection. Survival involving selection is the thing of interest to the biologist and sociologist. The word "fittest" is often used as if it meant "best," or at any rate most complex and most highly organized. It is particularly in its application to man that this reading of an ethical connotation into the "survival of the fittest" is to be deprecated.

The words "natural selection," whatever may have been the force of the objection at the introduction of the term, have now quite lost any suggestion of purpose and choice. Even the single word selection is coming to be used and understood as a generic term for natural selection, breeder's selection, "social selection"—if there be such a thing—and for any other forms of selection.

[2] For some it is in part, that is, in sexual selection.

domestic animals, on the other hand, mere survival is not enough. Where the breeder intervenes, propagation becomes the critical point. The breeder can use inferior cattle as draft animals. He favors some definite type for reproduction, but rejected individuals are not therefore destroyed. They may be put to some other use. Breeder's selection has, as we shall come to see, the character of reproductive selection. What Darwin, for the most part, dealt with as natural selection, we shall find it better to call lethal selection.

The root-idea of natural selection, and of selection in general, is segregation into classes distinguished by differences as regards continued existence of the type. One type is better adapted and survives, another is eliminated. Selection means, etymologically, a picking out and setting apart.[3] It is isolation in breeding. One eminent biologist and evolutionist, Romanes, would substitute this, as the more general term, for natural selection, and would make the latter but a species of isolation. If a superior type is to be evolved and preserved, breeding must be confined to those possessing in high degree the characteristics of that type. The most direct and sure way to isolate the fit and to prevent the propagation of unfit types is to kill off the unfit individuals. This is just what "nature" does. But there are other ways of attaining the same goal.

Darwin never attempted a formal classification of the forms of selection. He does name, and treat at length, one other form besides natural selection, that is, sexual selection. Other kinds, which are of comparatively little importance in subhuman species, he either altogether fails to distinguish or touches only casually. By his use of the term sexual selection, which he contrasts with "ordinary"[4] or natural selection, he does imply that the word selection is, by destiny, if not by established usage, a generic term, to be qualified by an adjective in order to indicate the various species of selection.

## The Four Kinds of Selection

We have now come to the distinctive purpose of this essay, that is a classification of the forms of selection having general applicability. I believe that adequate analysis—of course from the point of view of the sociologist, which is at the same time the most general point of view—gives us four species of selection, named as follows:

*Lethal selection.*
*Sexual selection.*
*Reproductive selection.*
*Group selection.*

These terms, some of which are already familiar, are now to be defined.

[3] Selection, by usage, is both the process and the result. And of the parts or aspects of the result, it is both negative (elimination) and positive (survival).

[4] Cf. "Descent of Man," sixth paragraph of Ch. VIII.

Darwin thought of natural selection chiefly as the elimination of individuals by death.[5] This is natural selection in the narrower sense. But it is better to avoid possible ambiguity by giving this kind of selection its distinctive name and separate treatment. It may appropriately be called lethal, that is death-bearing selection. Lethal selection, therefore, operates through the early elimination, or death, of relatively ill-adapted individuals. "Early" is here a relative term. Death operative by way of lethal selection occur either before physical maturity, or soon enough after to affect the amount of reproduction. Such death prevents the propagation of "unfit" characters.

Sexual selection depends on the advantage which certain individuals have over others of the same sex and species in respect of mating, and thus of reproduction.[6] It is due to sexual preferences which favor the mating of certain individuals as against others of the same species, and so cause more reproduction of certain characters than of others; or, in another form, it is due to differences between individuals of the same species as regards power forcibly to appropriate mates. The first of these may well be called æsthetic, and the second combative, sexual selection. Failure to mate, not failure to survive, is the mode of elimination in sexual selection. The individual must become adapted to the phenomena of sex within the species, as well as to outside "nature." "Selection in relation to sex" has an important part in Darwin's theory of organic evolution.

Among animals it is the relatively passive sex which exercises choice in æsthetic sexual selection, that is, usually the female. Hence the beauty and song of birds are male attributes. In combative sexual selection, on the other hand, the competition takes the form chiefly of actual fighting between rival members of the active sex. There is a difference between this struggle for mates and the "struggle for existence." "Nature, red in tooth and claw" is poetic license. The phrase gives no true notion of the workings of natural selection. The poet is apparently licensed to be inaccurate. The struggle for existence is chiefly a noiseless, inglorious effort to wrest from the environment sufficient food to maintain life. For the rest, some animals prey and others are preyed upon. It is only in combative *sexual* selection, however, that bloody combat, which implies a degree of equality of prowess, is the regular thing. It is significant, likewise,

[5] He says, for example, natural selection "produces its effects by the life or death at all ages of the more or less successful individuals." "Descent of Man," last paragraph of the section entitled The Male Generally More Modified than the Female, Ch. VIII.

[6] These are Darwin's words, with the significant difference that he says "solely in respect of reproduction." See "Descent of Man," fourth paragraph of Ch. VIII. He thus fails to recognize what is called in this article reproductive selection, for his sexual selection is clearly a different thing.

that the comparison of nature to a cock-pit uses phenomena, not of natural, but of sexual, selection.

Reproductive selection depends directly on difference in degree of fertility. If any quality is generally associated with a particularly high or low degree of fertility, it is at an advantage or disadvantage due to this form of selection. Reproductive selection is the case of influences bearing directly on propagation, apart from obstacles to mating, in a way relatively to diminish or increase the number of offspring from individuals possessing certain characteristics. The idea of reproductive selection is not developed by Darwin,[1] though it is fully in accord with his general theory and supported by his emphasis on propagation. It has little applicability to the lower animals, but for man it has very great importance.

Differences in ability to procure mates with resulting differences in number of offspring can be distinguished from differential results where the opportunity to mate and reproduce is equal. The former is sexual selection; the latter is reproductive selection. The two are related as pertaining to propagation exclusively, and are contrasted with lethal selection in that they do not involve the question of individual survival. Reproductive selection is a phenomenon of the diverse results of equal opportunities for sexual intercourse. Sexual selection is a matter of obstacles to mating, that is to getting opportunities for sexual intercourse at all. The former rests on differences between individuals as regards degree of reproductivity, granted mating. The latter turns on differences in degree of ability to obtain mates. Though an element of each form may be present in a particular case of selection, the distinction is important, especially in mankind.

In order that the individual shall be "selected" in the fullest sense, he must successfully run a threefold gauntlet. He must live to maturity and enjoy a long and vigorous prime. In obtaining a mate, or mates, he must be as successful as the "best" of his fellows. He must also, equally with the most favored of his species, possess and exercise the power to reproduce his kind and to hand down his characteristics to a numerous progeny. If he fails in the first particular, he is eliminated by lethal selection. If he fails at the second point, his kind is eliminated by sexual selection. If he fails in the third respect, his kind is eliminated by reproductive selection. In all these three particulars his failure need not be absolute, but may be a matter of degree, in which case the elimination is gradual. He may survive to maturity, but perhaps little beyond that. He may leave offspring that are too few in number as compared with those of his fellows. The critical question

[1] The name and idea are contributions of Professor Karl Pearson. See his essay "Reproductive Selection" in his "Chances of Death and Other Studies in Evolution"; also "Contributions to the Mathematical Theory of Evolution," III., in the *Philosophical Transactions of the Royal Society*, Vol. 188, p. 253.

always is: Whose descendants are to represent the future of the species? The question is one. But a decision may be rendered at any of several different points.

The three forms of selection so far mentioned apply to individuals. Group selection is recognized by Darwin, though not treated separately, nor by him distinguished from natural selection. Group selection results where a number of individuals act and suffer jointly, whether with conscious purpose or not, in matters affecting their success and survival in competition with other groups.[8] It is selection operating groupwise.

We have distinguished three forms of selection of individuals, over against which is now set group selection. It may appear that we should make a triple division of group selection, as we have of the selection of individuals. It is obvious, however, that the concept of sexual selection is entirely inapplicable. A group does not propagate its kind by a sexual relation with another group. Reproduction, of course asexual, might be predicated of a group. The idea of reproduction, however, as applied to the group, is but an analogy; and where so applied, it is of little or no significance for selection. Reproduction of its individuals is not reproduction of the group, for the group remains the same while its members change, just as does the body while its component cells die and are replaced by others. The group is thus potentially immortal and does not regularly reproduce itself. When a successful group becomes unduly large, it may divide or send out a "daughter colony," thus, so to speak, propagating itself by fission. But this is a question of size, not of differences in degree of natural reproductivity on the part of groups. As regards the "decease" of such a selectional group, moreover, it comes either by dissolution, that is, by the loosening of its bands and the dropping away of its members, or by their physical death. In the former case selection has not yet completed its work. In the latter case its work has taken an individual form. The ultimate incidence of group selection is always on individuals, affecting them either in the duration of their life or in their reproduction. But the effect is likely to be compound. From which of these two sorts of selection it comes, and how much is from one or the other form, are questions which have little importance from the point of view of the group. Therefore, if it is possible, it is not worth while, to attempt to subdivide group selection into lethal and reproductive forms.

Group selection is logically coordinate with all three of the other forms. In practise, however, taking account of its degree of importance, as well as of the fact that it is not to be subdivided, we may

[8] In the choice of terms, I have preferred to name the kind of selection from its characteristic means at the decisive point. But I have not been able consistently to hold to this terminology in the case of group selection.

treat it as on the same level with lethal, sexual and reproductive selection, constituting a fourth species.

It is repeating to say that successful reproduction of kind is the essential fact in selection. But the importance of the point is great enough to bear such a repetition. It is significant that Darwin got his idea from the practise of breeders of domestic animals, which is based upon the principle of reproductive selection. Lethal selection is more radical and more incisive in its methods, but death itself operates as a selective agency only through preventing reproduction. Elimination by death after the reproductive period is passed is not selectional. It merely makes more room for the new generation. Lethal selection comes through *early* death. It is probable that most animals die either when very young and immature or else after considerable reproduction. Survivorship tables for man exhibit the same general phenomenon, that is low mortality at the prime of life. Though we can not know all the possibilities of selection until we distinguish the four modes, they are not independent explanatory principles. All are reducible to effective propagation of kind, to success in leaving offspring. The fate of the individual as such, counts for nothing. For selection, the continuation or destruction of the line of descent is *the* thing. An individual is important only as belonging to or representing such a line of descent. The "struggle for existence" is only an incident, or a method, in selection. Selective propagation is what is essential.

The classification above presented is made with reference to the needs and point of view of the sociologist. One might well doubt whether the careful discrimination of reproductive selection, which has been attempted, would be at all justified by the little scope of application it finds among the lower animals. We know that sexual selection also has but limited applicability, and only to higher forms of life. In strictness, reproductive selection has been the factor that has, on occasion, adaptively increased the fertility of a species, no matter how low in the scale; while natural selection must have been the means of adaptively decreasing such fertility. But this is a minor point. Sexual selection seems to be the nearest that nature comes to admitting reproductive selection as an important factor. As regards domestic animals, also, what the breeder controls is mating rather than strictly and directly reproduction. This case well illustrates the difficulty of sharply discriminating reproductive selection. In man, however, fertility is extremely variable, by nature and through artificial means, so that we must, in man, take account of sheer natality, apart from other selective factors.[9] It is significant that the point of view of

[9] Perhaps it might be better, for this reason, to use the term "natal selection" for what has been called "reproductive selection," and reserve the latter for general use to cover both sexual and natal forms. But the term "natal" suggests germinal selection, and the idea of selection at birth or soon after would also be brought to mind, which is of course lethal selection.

the sociologist is, in the matter of selection, more inclusive, and more exhaustive of selective possibilities, than that of the biologist.

In our fourfold classification we have left out the term "natural selection." For its narrower, specific meaning "lethal selection" is decidedly preferable. Might not the older phrase be used as the generic name for all the forms of selection? Usage seems to favor this. "Selection," without a qualifying adjective, is logically the generic term, but is not yet so established as to be unquestionable. Natural selection is therefore convenient as a make-shift or substitute general term. It is familiar, and all the forms of selection do occur in nature. So, despite the implication of Darwin's practise in relation to sexual selection, natural selection might be used roughly for all four classes, though with a saving clause against including such a thing as purposive breeder's selection.

### Selection Applied to Man

In the attempt to apply selection to man, clearness of conception has often been lost. Two sorts of mistakes have been made. The complexity of life in civilized society, as compared with the simplicity of nature's conditions, has invited, on the one hand, to extensions of meaning, by which processes have been described as natural selection which are not selection at all. In particular, it has been supposed that segregation by economic or social success is selection. It is rather selective dissociation. This is an important preliminary to selection, but the incidence of the latter may as well be unfavorable as favorable to the survival of those who rise in the social scale.

There are, on the other hand, sociologists who deny that natural selection, meaning by that lethal selection, is of much significance for man. Such are likely to develop and emphasize contrasts between natural selection and what they chose to call "social selection." This is a conception for which the writer finds little use. Social selection should mean selection *by* society, and since society, unlike "nature," is to some degree conscious and purposive, social selection should mean more or less conscious selection by society. Whatever selection there is of this sort may still be brought under one of our four forms. But there are more, and more important, non-teleological sorts of selection resulting from characteristically social processes. And such phenomena of selection *in* society are what those who talk of social selection have chiefly in mind. These are provided for in our classification, though in distinguishing types use has been made rather of the method of the selection. To attempt to distinguish forms of selection according to the varieties of selective conditions would give an almost endless list, and the differences would not be of explanatory or scientific importance. We may speak of military or religious or industrial selection if we will, but these are descriptive terms rather than logical categories. This fact has not been perceived by those sociologists who,

rightly departing from the rough and ready practise which calls almost anything natural selection, have wrongly gone on to find about as many different forms of selection as there are social institutions and customs.[10]

As regards the scope of selection in general in its application to man, we are now prepared to believe that any influence that bears in any of the four ways enumerated upon the continuance of lines of descent presumably has selective importance. Only on the hypothesis of pure chance distribution of effects can any influence known to affect propagation be declared to be non-selective. The chances against this are infinity to one. No enumeration can cover all possible selective agencies. Every habit, custom and institution of man might well be examined with a view to detecting such effects. Selection must have tremendous importance in human society. It certainly is a central problem, perhaps the fundamental problem and point of departure, for a science of society.

Only the confounding of selection in general with mere lethal selection can explain the opinion that selection is inoperative in human society. Even so, the opinion is not well-considered, for there is much selection by death in civilized man. Lethal selection is not a matter of violent death, or death in struggle. The conception of natural selection as the result of a "free fight"—a *bellum omnium contra omnes*—has no justification in any phase of its application. Half the population of many civilized societies, and of course on the whole the weaker half, dies before reaching maturity. In the parts of the United States for which tolerable registration statistics are to be had, at least one third of the deaths are of persons under the age of fifteen. This involves lethal selection.

But lethal selection is not all. The forms and agencies of selection multiply as we pass upwards in the organic series. Hence we might expect a culmination, as regards manifoldness and complexity, in man. It is true that there are fewer births to select from, but the selection may come before birth, and in fact comes so always in the last analysis. And if there is less selection by death in man, there is also less random and indiscriminate destruction of human than of lower animal or plant life. The field for the study of selection in human society is as great and as complex as that in which the biologist works.

Of lethal selection in its application to man, little more need be said. Life-tables and deaths according to age tell the story. Lethal selection is not to be dismissed with the statement that men no longer habitually attack and kill one another, and in civilized states do not die for want of food. Of course selection by the dissolution of the weaker constitutions relates chiefly to physical qualities, but its im-

[10] Lapouge, in his "Les Selections Sociales," perhaps best illustrates this tendency.

portance for that is great indeed. Modern improvements in medicine and surgery may check the incisiveness of such action of selection. But they can only lower, not destroy, the standard set for survival. Lethal selection, however, even as regards mere physical qualities, amounts to much less for Occidental civilized man than for any other species of living thing. But some other species of selection are proportionately more important.

A weightier consideration that might appear to make lethal selection of less interest to the sociologist is the fact that it appears hardly to touch what is distinctively human in man's constitution, that is, his mental and moral qualities. But such selection does in fact promote mental stability, so far as the strain and stress of modern life drive men to insanity and death. Alcoholism, too, as is proved by the experience of life insurance companies, and by statistics of occupational mortality, tends to eliminate those who are in this respect deficient in self-control. In various ways the ignorant, the imprudent, and the vicious, tend to destroy themselves.

The effects of sexual selection are much more deeply marked in the organisms of birds than among mammals. The sexes in civilized man, however, show pretty clearly its differentiating influence. The greater strength of the male in man is probably due in part to sexual rivalry. As regards women, on the other hand, their conventional title, the "fair sex," is probably due to something more than mere chivalry or mere flattery. The pretty girl still marries better or earlier than her less "well-favored" sister. It is to be hoped that more important qualities than personal appearance are also favored by sexual selection.

Alfred Russel Wallace, the co-discoverer with Darwin of natural selection, though he curiously enough grudges recognition of it as a factor in the evolution of lower animals, apparently because it involves rather highly developed mentality, sees in esthetic sexual selection on the part of women the great means to the future progress of the human species.[11] With this opinion, the writer can not agree. Marriage is not so much a result of exclusive and exacting "elective affinities" that the relatively ineligible can not solace themselves with those of the other sex who are similarly situated. The approximate equality of sex numbers and the institution of monogamy, which forestalls monopolizing tendencies, leave no considerable class of persons eliminated by lack of opportunity to marry. Postponement of marriage on this account is probably of some influence, but of no great importance. Postponement of marriage and abstinence from it—the latter amounting to more than one fifth in some regions—are probably due to variation in the relative strength of the marital and repro-

[11] See his article, "Human Selection," in the *Fortnightly Review*, Vol. 54; also POPULAR SCIENCE MONTHLY, Vol. 38.

ductive tendency more often than to failure to find opportunity to marry. Sexual selection is probably still of some importance in man, though of problematic influence.

Reproductive selection is by far the most important of selective instrumentalities operating in civilized man. Here, and very recently, it has first come to great importance. One sixth and more of marriages in certain portions of civilized society are infertile. And differences in the number of children to a family are still more significant. This absolute or relative infertility must be more or less selective in its incidence. Nerve-racking indulgences and ambitions suggested or elicited by civilized life seem to create physiological conditions unfavorable to reproduction. Still more important is the fact that, with the increase and spread of physiological knowledge, the size of the family is placed under the control of volition, and children are no longer a necessary or to be expected result of sexual gratification. So the wish not to be bothered with children, with the moral traits it implies, leads to elimination. Over-cautiousness and desire to pamper children, on the other hand, resulting in the so-called "two-child system," bring about, though more slowly, the same result. The over-cautious in such matters certainly will not "inherit the earth." Conscientiousness on account of transmitting physical weaknesses acts in the same way. Celibacy as a religious observance has probably taken from society some of its gentlest natures.[12]

An average of nearly four children to a family is necessary to keep up the numbers of a population. For a family to have fewer is likely to mean that it will have less representation in the next generation than in the present. Such a family is certainly not holding its own in a country of increasing population like the United States. Hence the plaint of "race suicide," which is in fact never *race* suicide, but only the self-elimination of a particular section of society. The blood of France may become Breton, but it not at all likely that France will lose its population. The New England stock, which populated the West, is probably now declining in numbers in its old home by deficiency of natural increase.[13] But New England is gaining population. There are always relatively and absolutely fertile elements in society, as well as the relatively infertile. The significant thing is what are their differences as regards mental and moral traits. Is "race suicide" due more to selfishness or to over-caution? Is high fertility due more to improvidence or to the love of children? How far is a high standard of life associated with the most desirable mental traits?

[12] Galton notices this selectional influence as early as 1869, in his "Hereditary Genius," though of course without distinguishing it as reproductive selection.

[13] See articles of R. R. Kuczynski in the *Quarterly Journal of Economics*, Vol. XVI.

Clearly reproductive selection is the most important selective influence in present social evolution.

Men act and suffer jointly. Man is a social animal, and he is such through adaptation. Primitive man, like many lower animals, associates himself with others for mutual protection and support. Hence the strength of tribal attachment and of clannishness. To group selection chiefly is to be attributed capacity for cooperation and those feelings of regard for others on which morality is based. The attachment of mother and child is primeval and of course strongest. But the family, created by the presence of the father, is the earliest persistent, truly social group. Still more characteristically social is the bond of union between grown-up brothers and sisters. Out of kinship grouping has grown the broader, though vaguer and less intense, recognition of fellowship contained in morality. Morality has been called the egoism of the group. When developed and refined, it is much more than that, but it is based upon the instinct that draws men together.

Group selection is probably at its best in primitive man. Bagehot's classic discussion of the evolution of a coercive social organization is an application of group selection. But in modern occidental society the process of individualistic atomization has been carried so far as to threaten the disintegration even of the family. Large family, clan, tribe and village community are gone. There is left little but the individual, or the natural family, and the state. What "groups" there are between the state and the family are largely mere expressions of an appetite for association which finds no other and more important object upon which to exercise itself. And the state is of no importance for group selection. It has become a thing of contrivance and a matter of social psychology. The family is the only group left that is of much selectional importance. Of progressive national states there are too few, in the face of the many questions to be answered, to offer the necessary material. And they interpenetrate by migration in a way to defeat selection groupwise.

Selective dissociation is so closely related to selection, and so often confounded with it, that it requires mention here. There is selective dissociation where individuals of more or less similar traits are segregated from others and put into a special environment of a nature to affect their survival.[14] The incidence of the forms of selection varies with geographical region and social class. The process of dissociation is not directly selection, but only indirectly important as its preliminary.

Economic and social rise has been mentioned as often confused with "survival." Survival it is not, but merely selective dissociation

[14] The term "dissociation" is used by C. C. Closson in articles in the *Quarterly Journal of Economics*, Vols. X. and XI.

of those possessing traits making for success. It probably means selectional disadvantage, owing to the heavy incidence of reproductive selection on "successful" families.

International migration to a new country is another case of selective dissociation. The American colonists were undoubtedly, on the whole, men of superior initiative and independence of character. Their coming to America made possible the multiplication of their descendants and their kind. Even our present-day immigrants are rather superior in point of energy to those of the same economic condition who remain behind, and they come to an environment presenting greater opportunities.

Urban migration is a notable example of selective dissociation. According to the indications of anthropological and other evidence, it is the more energetic element that migrates from country to city. Under conditions prevailing down into the nineteenth century, cities could not maintain their population by natural increase. Migration to the city then meant subjection to an unusually severe incidence of lethal selection. Our modern sanitary improvements have not yet entirely removed the disadvantage of the city as compared with the country.

We have mentioned selection *by* society as possible, but not a very important fact. The execution of criminals and their imprisonment, so far as it prevents reproduction, are cases of such selection. In crueller ages, with numerous capital crimes and many executions a year, this may have been an important mode of selection. Now it amounts to little. Perhaps public opinion, also, puts certain members of society under some selective disadvantage.

Francis Galton has proposed that society deliberately undertake the improvement of the human stock.[15] He would have certificates of fitness issued and suggests the giving of marriage portions to girls of superior personal qualities and good family. Such a program of "eugenics" would operate through reproductive selection. It is an interesting proposition, if not very practical. Hitherto the method of evolution has been essentially negative, that is, primarily the elimination of the unfit. Will any human society ever be wise enough positively to map out the line which further evolution shall take? The definition of what is *un*desirable is much simpler than the definition of what is *most* desirable.

In the above brief review of the incidence of selection in man, it has been the intention of the writer merely to give examples illustrative and suggestive of the applicability and importance of the dif-

[15] POPULAR SCIENCE MONTHLY, Vol. 60, article at page 218. He has also brought up the subject before the British Sociological Society. Reports of the discussion are printed in recent volumes of the *American Journal of Sociology*, as well as in the society's Sociological Papers.

ferent forms of selection for the study of man and his social evolution. An extended treatment of this subject is one of the great desiderata of the science of sociology, the half of which will be the theory of selection in its application to man.

A logical and seemingly very forcible objection to the idea that selection applies to man is contained in the contention that heredity has nothing to do with the higher, which are the distinctively human, qualities in human nature. But the common-sense and practical view is that even the highest intellectual and moral qualities are to some extent inheritable. Men look for family traits not merely in the physical features of children. There is certainly a tendency to the inheritance of insanity, which shows that mind is subject to heredity. It is enough for the purposes of the sociologist if the inheritance of the properly human qualities be only statistically true, that is, true for the mass, though not true of every individual. In fact, this is what we should expect. For a number of reasons variation should be at its best in characteristics distinctively human. Biologically viewed, man is like a domestic animal and is a dominant species, both of which facts imply great variability. There is also approximately unrestricted crossing in mankind. The environment, that is complex civilized society, demands diverse specialized qualities; so that the external conditions favor multilinear evolution. The distinctively human qualities have been latest acquired and are therefore most subject to variation. In man, moreover, as the most socialized of animals, much may be left to imitation and education, that is, to "social heredity." Hence there is less need of a hard and fast physical heredity.

The fact that the line of least resistance in development is the resultant of two sets of forces, internal (variation and heredity) and environmental (selection), must not be allowed for an instant to slip the mind. The interdependence and delicacy of adjustment between these forces increases with the complexity of man's higher, special characteristics. Hence the apparent decrease in the importance of heredity. The distinction between what is innate and what is acquired often hinges on mere ease of enumeration of cases of apparent predominance, or relative independence, of one or the other factor. Or the results are referred to the least easily assumed to be constant factor. Such is in practise man's application of causation. Both sorts of factors are always necessarily operative. It must be granted that proper inheritance is a necessary precondition to the appearance of noble qualities, and this alone concedes the presence and importance of heredity. Both internal constitution and modifications from without are determinants of development and man can no more get along without the right sort of heredity now than ever. Complexity and lack of fixity in development do not remove from the sphere of heredity, though they do mean greater possibilities and greater likelihood

of variation. They do also give opportunity for the development of a new set of factors in evolution, the socio-psychical. It can not be too strongly emphasized, however, that these socio-psychic factors are conditioned by their foundation in the innate qualities and capacities of human nature, that is, in the characters given to men by selection.

It may be that the power of heredity is limited short of the powers of evolution and development. But this does not seem to be true for the higher moral qualities, nor for conspicuous intellectual power, though it is perhaps well to add the caution that heredity appears to be not yet thoroughly established for these qualities. But selection itself can make heredity more stable. It would be enough for the most utopian sociologist if all human beings could be brought up and kept up, by the fixation of heredity, to the present highest level of intellectual power and moral character. So much progress selection may accomplish. Whether it does, depends on the adaptation of human institutions to such remote ends.

The question as to the applicability of natural selection to man can not be satisfactorily dealt with as one simple whole. Here as elsewhere analysis is the necessary instrument of science. By analysis we discover four distinct modes of selection: lethal, sexual, reproductive and group selection. We find, also, that these four forms have very different sorts of applicability in the explanation of man's evolution, past and present. Especially under present conditions it is reproductive selection that most calls for consideration.

In these days "race suicide" is a much talked of subject. There is plenty of occasion for the discussion. But the fact that attracts attention is not rightly called race suicide. Literally interpreted, race suicide is an absurdity. The actual fact that is attracting attention is a phase of reproductive selection. Its importance can hardly be exaggerated. But it can be truly evaluated only as seen in its setting as a phase of a form of selection. The fear of race suicide as a matter of *quantity* of population is no more valid or justifiable—it is rather far less justifiable—than the contrary and equally unanalytic fear of over-population awakened in Malthus and his followers a century ago. The question is not so much one of *quantity,* either by excess or deficiency, as of *quality* of reproduction and of population. It is therefore a question of selection. In this matter of selection in mankind it is doubtless true that "race suicide"—if the term means the self-elimination of certain classes of members of society—now plays the most significant part.

# ILLUSTRATIONS OF MEDIEVAL EARTH-SCIENCE

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C'est vers le Moyen Age énorme et délicat,
Qu'il faudrait que mon cœur en panne naviguât.
—PAUL VERLAINE.

MODERN experimental science dates only from the sixteenth century. The habit of interrogating nature, the application throughout all departments of research of the observational and inductive methods, the thirst for fresh discovery and invention, and the irrepressible curiosity that inquires into the innermost recesses of the wonderful world we live in, seeking to ascertain its laws and acquire mastery over its forces—all these leading characteristics of modern science were absent from its medieval prototype.

In reality, the so-called science of the middle ages is scarcely worthy of the name. Infinitely inferior as compared with modern science, it was still more crude, more distorted, more fantastic and illusory than that of ancient times. Medieval man had no clear-eyed perception of the visible world, actuality possessed for him little value, that which really is and happens was without special significance in his eyes. What the medieval man saw he interpreted as a symbol, what he heard he understood as an allegory. Dante himself is our best witness that cultivated men of his age esteemed the speculative life vastly superior to the practical.

Under the conditions of hopeless barbarism that existed from the seventh to the eleventh century there could be no real culture, and intellectual activity continued at an extremely low ebb. Religion absorbed almost all other occupations of the mind, faith was exalted as a sovereign virtue, mere empirical knowledge was disdained and rejected. As the Christian religion became the leading subject of men's thought and interest, so the principal business of their lives throughout the middle ages was the salvation of their souls. External conditions were unpropitious, subjective conditions inhibitory for the development of scientific ideas. Hence it was inevitable that learning should become decadent, and the proud record of ancient achievement forgotten. Indeed, as early as the fourth century of our era, before all relics of the old culture had disappeared, Eusebius wrote:

It is not ignorance which makes us think lightly of science in general, but contempt for its useless labor, while we turn our souls to better things.

Two centuries later Pope Gregory the Great protested against the study of pagan literature,

> because the praise of Christ and the praise of Jove are not compatible in one mouth.

Again in the tenth century, a period of utter stagnation, illumined by scarcely a ray from classical antiquity, church dignitaries maintained that

> the successors of St. Peter wish for their teachers neither Plato nor Virgil, nor Terence, nor any other of the philosophic cattle.

But with the revival of learning during the next two hundred years came a change for the better, and medieval knowledge began to assume a more positive character. Its science, still contaminated with the errors and superstitions it had received from remote ages, gradually became less chaotic, less fantastic and symbolic, less dominated by theology, although for a long time after its subjection to scholastic influences it remained, so to speak, Aristotelized. That is to say, logical analysis was relied upon for ascertaining all manner of truth, a complete system being devised toward that end by Raymond Lull. The independent searching out and testing of actual facts, the process of drawing general conclusions from concrete phenomena, were not the methods employed by medieval schoolmen, with the one notable exception of Roger Bacon.[1] It was commonly held that all truth may be obtained by the use of reasoning alone; and "that by analyzing and combining the notions which common language brings before us, we may learn all that we can know. Thus logic came to include the whole of science." (Whewell.)

There can be no doubt that the universal reverence for Aristotle's authority, and blind acceptance of other accredited doctrines and treatises, greatly retarded scientific progress. All men begin their development with a childlike trust in authorities and examples, and as science had to be regenerated *de novo* toward the end of the middle ages, it is only natural that its beginnings should appear to us lamentably weak and puerile. Moreover, the system of instruction employed by Catholic schoolmen was not conducive to real enlightenment. The real difficulty, as has been pointed out, is that "not life and nature were the basis of instruction and science, but books. Not the thing itself was the object of inquiry, but the word; not experiment disclosed the truth, but dialectics." Authority had greater weight than arguments, and in the last resort authority depended more upon a master's reputation than on his knowledge. Finally, we must not forget the restraint imposed upon medieval philosophy by theology. Religious discipline required that the results of human reason should be con-

[1] On Baconian contributions to science, see Professor Holden's interesting article in POPULAR SCIENCE MONTHLY for January, 1902 (60: 255).

formable to church dogmas, and woe to him who dared insinuate that whatever was taught by the church was not also the logical outcome of human reasoning.

Thus, freedom of the intellect had to contend not only with formidable difficulties imposed from without, but with no less effective hindrances, wrong conceptions and limitations that came from within. While these conditions lasted the net result was sterility. In time, however, that innate longing to escape the bonds of ignorance, that patient and zealous striving after truth which stimulates all lofty endeavor, these impulses gradually became more assertive; and, triumphant at last, gave rise to our modern critical science.

It would be impossible to attempt here even a superficial sketch of the remarkable rise and expansion of empirical knowledge that took place during the twelfth and thirteenth centuries, by virtue of which Dante's era merits its appellation of *secolo d'oro*. The innumerable commentaries that have been devoted to the most striking figure of the middle ages attest the difficulty of preparing an adequate survey of contemporary knowledge. Remember, too, that the peerless poet stands out from the midst of a notable company of erudite laymen and clerical scholars. It will be sufficient to recall only such names as those of Ser Brunetto Latini, whom Dante expressly calls his 'master,' and whose encyclopedic work embraces practically all the science of his time; Albertus Magnus, often styled the "Universal Doctor," and his famous disciple, St. Thomas Aquinas; those brilliant Anglican geniuses, Roger Bacon and William of Ockham, forerunners of the modern spirit of investigation; and those twain Italian luminaries whose souls were fired with the glow of ancient and of the newly revived culture, Petrarch and Boccaccio. Still earlier, and entirely independent of Christian influences, the Arabian circle of sciences had gained new luster from Averroës, its chief exponent and adornment.

But besides these greater lights there shone many of feebler intensity, yet none the less worthy of grateful esteem, since their combined rays helped toward clearness of vision. There was one erudite scholar, for instance, who was formerly rated as a mere imitator and plagiarist of Albert of Bollstädt; whereas we now know that the reverse was true, in that the master drew largely upon his disciple for materials in preparing his huge compendium on natural history. This was Thomas of Cantimpré, who wrote during the third and fourth decades of the thirteenth century, and whose works were widely read and translated. His chief contribution to science was a treatise entitled "De naturis rerum," which served at once for the source and model of Conrad of Megenburg's "Buch der Natur," the earliest of its kind to be written in the German vernacular.[2]

Conrad, however, considerably amplified the work of his Brabant

predecessor, and is further interesting to us for displaying power of original observation. He had also the happy faculty of meditating upon his observations, and was by no means averse to offering his own explanation of the causes of various phenomena. Accordingly, it has seemed worth while to reproduce a passage from this author relating

ALBERTUS MAGNUS.

to earthquakes, for the reason that it offers a very fair presentment of the status of geological speculation among medieval schoolmen. The second illustration has been selected with similar intent from the "Cosmography" of Ristoro of Arezzo, written in 1282. Dante's acquaintance with Ristoro's work has not been definitely proved, but is regarded by competent authorities as highly probable.

[2] A modern German edition of the text was published by H. Schulz in 1897. The most recent study of Thomas Cantipratanus is by a Dutch author, Dr. W. A. Van der Vet, entitled "Het Bienboëc van Thomas van Cantimpré," 1902.

## On the Nature and Causes of Earthquakes

(Extract from Conrad of Megenburg's "Buch der Natur," 1359)

The fourth and nethermost element is the sphere of earth. Its distance from the firmament [of the fixed stars], as determined by divers scientific men, both pagan and Christian, is 309,375 miles. No one can impugn the accuracy of this result, depending as it does upon laborious calculation and the reduction of very delicate astronomical observations. None but unlettered folk contemn such investigations. Ignorant persons are unable to comprehend that a geometer may station himself outside the town and accurately determine the height of turrets within the town by means of angular measurement. Yet in sooth is it possible. By a similar method we ascertain the distance from earth to the starry heavens.

The earth is the only one of the four elements that is favorably adapted for man; it is peculiarly his province, as heaven is the habitation of God and the angels. The earth element alone is innocuous to man, the others often injure him. For water drowns, foul air suffocates, and fire consumes him. The earth is by nature cold and dry, externally harsh, yet concealing within its bosom full many beauteous things, such as precious stones and the noble metals. By a like token, many an humble citizen may possess jewels within his heart. The earth-realm is very luxuriant, and the only one that brings forth fruit in abundance. How many miles it measures in circumference, and the extent of its diameter, I have already set forth in another place,[3] and likewise have explained the cause thereof, why it does not fall away from its abode in space. As the heart is lodged within the mid-portion of the body, so is hell seated at the center of the earth. Thus do our reverend masters instruct us.[4]

Oft it happens that the earth trembles, causing cities to fall, and mountains to crash together. Simple folk know not the reason of this, but foolishly believe that the earth is borne up by a mighty fish, which carries his tail in his mouth; and the turning or moving about of this creature causes the earth to shake. But this is a myth.[5] Remains for

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[3] Conrad's data as to the dimensions of the earth and its distance from the several heavens are possibly derived from the same source as Dante's and Brunetto Latini's, namely, the *Elementa Astronomica* of Alfraganus, cap. xxi. Roger Bacon's calculation of the earth's circumference was only one-fourteenth smaller than the truth, and Ristoro's independent reckoning of the latitude of Arezzo, in 1282, was in error to the extent of little more than one degree.

[4] S. Thomas Aquinas teaches with regard to hell that it is probably situated under the earth and that its fire is of the same kind as terrestrial fire, an *ignis corporeus*. (*Summa theol.*, Suppl., Pars iii., Qu. 97.)

[5] Probably an echo of ancient Titan myths, though having affinity also with the Arabian voyages of Sinbad. The existence of a great sea-monster was a very popular legend in the middle ages, the creature being sometimes identified

us to give true relation of this marvel, and to explain the cause of its occurrence. Now earthquakes originate in this manner, that within subterranean cavities, and especially in the interior recesses of mountains, vapors are compacted together in such vast quantities, and under such tremendous pressure, as to exceed at times all means for restraining them. They crowd in all directions against the walls of the interior caverns, fly from one to another of them, and continue to augment in volume until they have surcharged an entire mountain. The increase of these vapors is occasioned by the stars, especially by Mars and Jupiter. When now the vapors are confined for a long period within the subterranean cavities, their pressure becomes so prodigious that they burst forth with enormous violence and rend mountains asunder. Even when they fail to break completely through the crust they are yet able to produce a severe shock.

There are two kinds of earthquakes. Those of the first sort cause a gentle swaying of the ground like the rolling of a ship at sea. This movement is least destructive of fortresses and houses. The reason for this is that the vapors upheave the crust in a single supreme effort, and thereupon relapse in energy. Disturbances of the second sort are those which produce tremblings of the crust by means of a succession of sudden shocks, the motion being comparable to that of hand-shaking. Their effect upon buildings is most disastrous, solid masonry being shattered and hurled down by them. The process involved in this class of earthquakes is that one vapor rushes in pursuit of another, and drives it violently from side to side.

That the causes are verily as we have described is supported by abundant evidence. First, when a catastrophe is about to happen, premonitory rumblings are heard that resemble nothing so much as the noise of an hundred thousand hissing serpents, stridulating in chorus; or again there may be bellowings like unto those of maddened bulls. These sounds proceed from the violent agitation of the vapors within the interior of the earth, forcing their way through crevices and struggling to become liberated. Secondly, the sun shines feebly, or appears reddish-hued by day, owing to the heavy pall of smoke that rises from the earth's surface and obscures the view. Thirdly, it is well known that immediately after an earthquake the air becomes virulent, so

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as Cetus (the whale), or the Craken of the north, or again merely as a gigantic fish. In the bestiary of Philippe de Thaun the incident is given in a few lines beginning:

> "Cetus ceo est mult grant beste, tut tens en mer converse,
> Le sablun de mer prent, sur son dos l'estent."

The monster reappears under the name of Jascom or Jasconius in the old Celtic legend of St. Brandan:

> "Jascom he is i-cleped, and fondeth nite and dai
> To putte his tail in his mouth, ac for gretnisse he ne mai."

that many people die. The reason for this is that when the vapors have been confined for a long time underground they become fetid and noxious. The same thing happens in wells that have long remained foul and choked up, for when these are again opened for cleansing purposes, the first workmen to descend into them are often asphyxiated.

Many wondrous effects are wrought by earthquakes. Note first that the vapors escaping at such times frequently transform men and beasts into stone, especially into rock-salt, and this is very liable to happen in mountainous regions or in the vicinity of salt-mines. This lapidifying property of the vapors is due to their enormous condensation. So affirm the eminent doctors of science. And I myself have heard it reported that high up in the Alps as many as fifty neatherds with their beeves were turned to stone in this manner; with them also was a dairymaid engaged in drawing milk, and transfixed in that attitude at the selfsame moment when all were petrified. Note secondly that earthquakes are often accompanied by flames and glowing ashes which shoot up from below and ignite houses, villages and towns. Yet a third accompaniment of earthquakes is the belching up from below of vast quantities of sand and dust, sufficient to engulf whole cities.

### Concerning the Processes of Mountain Formation

(From Book VI., Chapter 8, of Ristoro d'Arezzo's "Composizione del Mondo," 1282)

And we have ourselves discovered and excavated near the summit of an exceedingly high mountain remains of numerous species of fish and other creatures, such as various members of the shark tribe, and even shells that had retained traces of their original coloration. And in the same locality are found also different varieties of sand, gravel, water-worn pebbles and boulders scattered about in great profusion, apparently deposited by aqueous agency: and this we consider proof that the mountain in question was formed by the flood.

And we have at another time ascended a lofty mountain whose summit was composed of a thick stratum of very hard rock, of ferruginous color, and whose structure was as clearly the work of design as a vase is evidence of the potter's art. A huge castle, almost a citadel in fact, rested upon cliffs of this formation, and all the strata outcropping at that altitude reposed upon other beds that had plainly been formed by water action. And the proof thereof consists in this, namely, that as one examines the strata exposed along the flanks of the mountain, one finds in certain places earth commingled with sand, at others tufa along with stones rounded by water action, and again elsewhere, quantities of fish remains belonging to various species, and also numerous other beds of divers kinds; all of which proves that this particular mountain, and the others already mentioned, near

whose summits occur fish remains, were formed by the deluge. Yet this same catastrophe may very readily have formed other mountains which do not contain sand and fish remains, the difference being occasioned by the nature of sediments existing in particular localities. Such, then, is the process of mountain-making. And the reason why mountain chains must have been formerly sea-bottom, or deposited in marine basins [before their upheaval], is that the volume of fossiliferous and arenaceous sediments is far too considerable to be ascribed to the agency of rivers, or of any other body of water inferior to the sea itself. . . .

[The continuation of this passage is devoted to seismic and volcanic phenomena, which are discussed more particularly in a subsequent section (Distinzione vii. parte iv.). The author expresses himself upon these questions, as well as upon the meaning of fossils, erosive action of water in molding land surfaces, scintillation of the stars, etc., in eminently scientific manner. His elder contemporaries, Albertus Magnus and Vincent of Beauvais, also note the existence and teaching of fossil remains. Similar inferences are drawn by Cecco d'Ascoli, the ill-fated author of *l'Acerba* and envious rival of Dante in the latter part of the thirteenth and first quarter of the fourteenth century.]

## THE PROGRESS OF SCIENCE

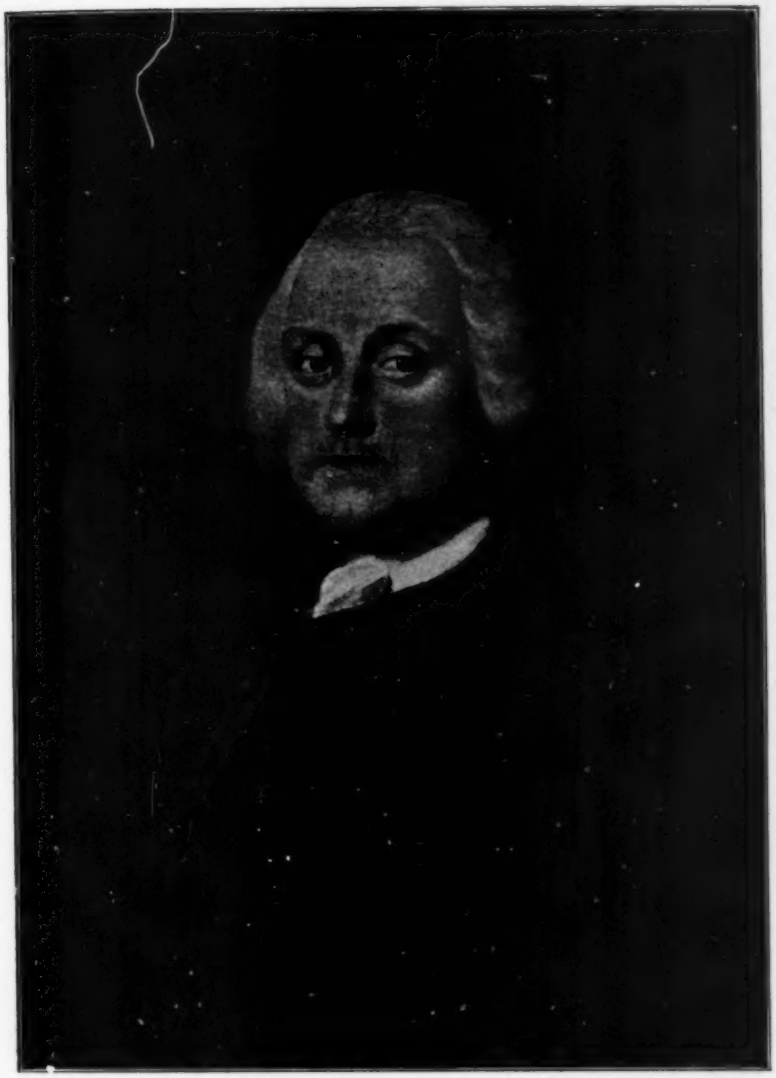
### *BENJAMIN FRANKLIN AND THE AMERICAN PHILOSOPHICAL SOCIETY*

THE celebration of the two-hundredth anniversary of the birth of Franklin, held at Philadelphia last year under the auspices of the American Philosophical Society, has now been completed by the publication of a volume containing a full account of the proceedings. These proceedings were unusually impressive. The Pennsylvania legislature made an appropriation of $20,000, and all the arrangements were carried out with admirable skill by the officers of the society. The commemorative addresses by Dr. H. H. Furness, President Chas. W. Eliot and the Hon. Joseph H. Choate are models of thought and expression. A special session was held to honor Franklin's researches in electricity, when addresses were made by Professor E. L. Nichols and Professor Ernest Rutherford. It is not necessary to repeat here all the features of the program, but attention may be called to circumstances which give opportunity to reproduce from the volume two interesting portraits of Franklin.

At the instance of the committee of the society, the congress passed an act enabling the secretary of state to have struck a medal to commemorate the two-hundredth anniversary of the birth of Franklin, one single impression in gold to be presented to the Republic of France and one hundred and fifty copies in bronze to be distributed by the president of the United States and the American Philosophical Society. The medal, designed by Louis and Augustus St. Gaudens, has under the face of Franklin the words "printer, philosopher, scientist, statesman, diplomatist," while on the reverse history writes in the presence of Literature, Science and Philosophy. This medal was presented by the secretary of state, the Hon. Elihu Root, and accepted by his excellency the French Ambassador, M. Jusserand.

The occasion of the Franklin bicentenary was taken by Lord Grey to present to the United States a portrait of Franklin painted in London in 1759 by Benjamin Wilson. This portrait hung in Franklin's house in Philadelphia, whence it was taken by Major André and given by him to the great grand-

THE FRANKLIN MEDAL.

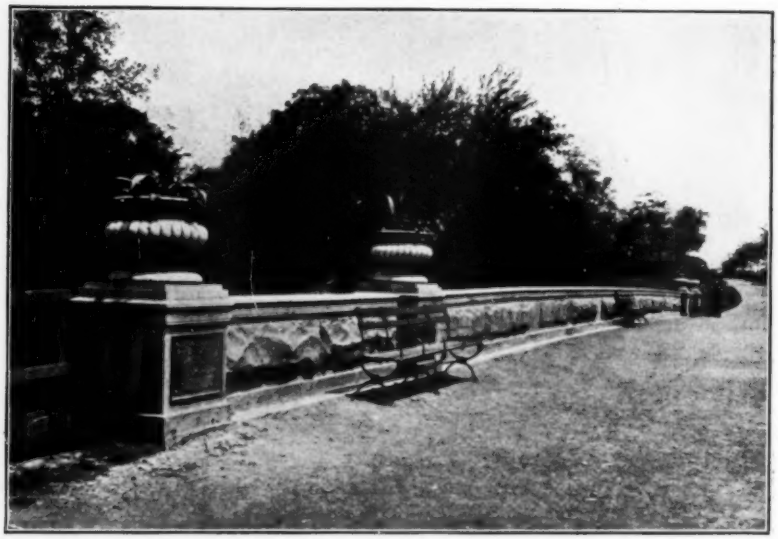


PORTRAIT OF FRANKLIN PAINTED BY BENJAMIN WILSON IN 1759.

father of Lord Grey. In the letter, read by the Hon. Joseph Choate, when the portrait was first shown after its return to this country, Lord Grey says:

In a letter from Franklin, written from Philadelphia, October 23, 1788, to Madame Lavoisier, he says: "Our English Enemies, when they were in possession of this city and my home, made a prisoner of my portrait and carried it off with them."

As your English friend, I desire to give my prisoner, after the lapse of 130 years, his liberty, and shall be obliged if you will name the officer into whose custody you wish me to deliver him. If agreeable to you, I should be much pleased if he should find a final resting place in The White House, but I leave this to your judgment.



BRIDGE OVER THE BRONX RIVER, BETWEEN THE NEW YORK BOTANICAL GARDEN AND THE NEW YORK GEOLOGICAL PARK, DEDICATED TO THE MEMORY OF LINNÆUS

## *THE CELEBRATION OF THE BI-CENTENARY OF THE BIRTH OF LINNÆUS BY THE NEW YORK ACADEMY OF SCIENCES*

THE two-hundredth anniversary of the birth of Carolus Linnæus has been celebrated throughout the world, notably by the Royal University of Upsala, where he was professor from 1741 to his death in 1774, and the Royal Swedish Academy of Sciences, of which he was the first president. Of the many local celebrations, we may select for mention that under the auspices of the New York Academy of Sciences, where the arrangements were more elaborate than elsewhere in America. The morning of May 23 was devoted to exercises in the American Museum of Natural History, the afternoon to exercises at the New York Botanical Garden and the New York Zoological Park, the evening to exercises in the Brooklyn Institute of Arts and Sciences and the New York Aquarium. At these different scientific institutions addresses were made by Dr. J. A. Allen, Dr. P. A. Rydberg, Mr. F. A. Lucas and others. The building of the New York Aquarium commemorated the centennial of its erection, and the collections were opened for the first time by night.

Of special interest was the dedication to the memory of Linnæus of a bridge over the Bronx River on Pelham Parkway between the New York Botanical Garden and the New York Zoological Park. The bronze tablet, presented by Dr. N. L. Britton for the New York Academy of Sciences, bears these words:

Linnæus, botanist and zoologist, born Rashult, Sweden, May 23, 1707; died Hammarby, Sweden, February 18, 1778. This bridge was dedicated by the New York Academy of Sciences, May 23, 1907.

A cable message addressed to the New York Academy of Sciences by the Swedish Academy reads as follows:

To every Swede, and especially to our society, whose honor it is to count Carl von Linné as the greatest ornament of its ranks, it is highly gratifying to see that the memory of the man whom all the world recognizes as Princeps Botanicorum is also held so sacred across the Atlantic that the two hundredth anniversary of his birth will be celebrated there with the same love and reverence as in his own country. And we fully appreciate the delicate courtesy which has led you to immor-

talize his name among you by dedicating to him the beautiful bridge which unites your Botanical Garden with the Zoological Park.

## THE STATE UNIVERSITIES AND THE SYSTEM OF RETIRING ALLOWANCES OF THE CARNEGIE FOUNDATION

In Mr. Carnegie's original letter giving $10,000,000 to establish a fund for pensioning professors, denominational institutions, on the one hand, and state institutions, on the other, were excluded. In the act of incorporation, however, the question of the state institutions was left open, and it was at one time reported by the newspapers that Mr. Carnegie would add five million dollars to the foundation in order that they might be included. But it now appears that the opposite policy will be followed. The documents on the subject presented to the trustees have been printed as a bulletin of the Carnegie Foundation. This bulletin, in addition to giving the grounds that have been urged for and against the policy of granting pensions to professors in the state institutions, contains some interesting data in regard to the development of these institutions.

The executive committee of the National Association of State Universities drew up a statement for the trustees in which they urge the following reasons for including these universities under the auspices of the fund: State universities are not controlled by religious denominations; they maintain college standards based on the high school; they have an assured income equal to the productive endowment required for private foundations; state institutions can not establish a pension fund as this might raise the whole question of pensions for state officers; the omission of these institutions discriminates against the professors who have served them; the plan would not weaken support by the states. Memoranda in favor of granting allowances were also presented by Dr. Maurice Hutton, acting president of the University of Toronto, and by Professor Henry T. Eddy, dean of the graduate school of the University of Minnesota.

Dr. Henry S. Pritchett, president of the foundation, discusses these papers, and comes to an adverse conclusion. He holds that from the point of view of general policy, professors in the state institutions should receive retiring allowances, but that these should be established by the states themselves, as the granting of allowances by a private agency might lessen the sense of responsibility of the states for educational support. He states that to add to the list of accepted institutions all state universities would be to complete the list of institutions for which the foundation can provide an adequate retiring system. He holds that the award of pensions to a large number of representative institutions by the foundation will make the plan part of the American Educational System, which other institutions will necessarily follow.

It may be that in this matter the trustees of the Carnegie Foundation, nearly all of whom are presidents of private institutions, are not entirely disinterested. Some of them have given occasion for such inference by their attitude toward a national university, which Mr. Carnegie at one time planned to endow. In the establishment of libraries, Mr. Carnegie has not been indisposed to cooperate with institutions supported by taxation. However, it does not follow that in the end it would have been to the advantage of the state institutions to have been placed under the Carnegie Foundation. There are dangers, as well as advantages in centralization and uniformity. It by no means follows that compulsory retirement at the age of sixty-five, on part salary is the best plan. Perhaps the state universities may adopt the German system, by

which the appointment of a professor is for life, he being excused from active service when disabled by illness or old age.

### *SCIENTIFIC ITEMS*

WE record with regret the deaths of Sir Benjamin Baker, F.R.S., the eminent British engineer; of Dr. Alexander Buchan, F.R.S., the Scottish meteorologist; of Sir Joseph Fayrer, known for his pathological work in India, and Dr. Charles Féré, known for his researches in neurology and psychiatry.

THE honorary freedom of the City of London is to be conferred on Lord Lister.—The gold medal of the Linnean Society, London, has been awarded to Dr. Melchior Treub, director of the Botanical Garden at Buitenzorg.

A SECOND series of tablets was unveiled in the Hall of Fame, of New York University, on Memorial Day, May 30. Addresses were made by Governor Hughes, of New York, and Governor Guild, of Massachusetts. Among the twelve tablets unveiled was one in memory of Maria Mitchell, the astronomer, and one in memory of Louis Agassiz. The tablet in honor of Agassiz was unveiled under the auspices of the American Association for the Advancement of Science with brief addresses by Dr. Charles D. Walcott, secretary of the Smithsonian Institution, and Dr. Edward S. Morse, director of the Peabody Institute of Science.

THE committee of one hundred, appointed by the American Association for the Advancement of Science to further the promotion, of national interest in health, met in New York City, April 18, and organized by the adoption of rules, the election of officers and the appointment of an executive committee. Professor Irving Fisher, of New Haven, presided as the temporary chairman and was subsequently elected president. Ten vice-presidents were elected, as follows: President Charles W. Eliot, Harvard University; Dr. Felix Adler, New York; Dr. William H. Welch, Baltimore; Rev. Lyman Abbott, New York; President James B. Angell, University of Michigan; Miss Jane Addams, Chicago; Hon. Joseph H. Choate, New York; Rt. Rev. John Ireland, St. Paul; Hon. Ben. B. Lindsey, Denver; Hon. John D. Long, Boston.